DESIGN edition

NOVEMBER 25, 1957

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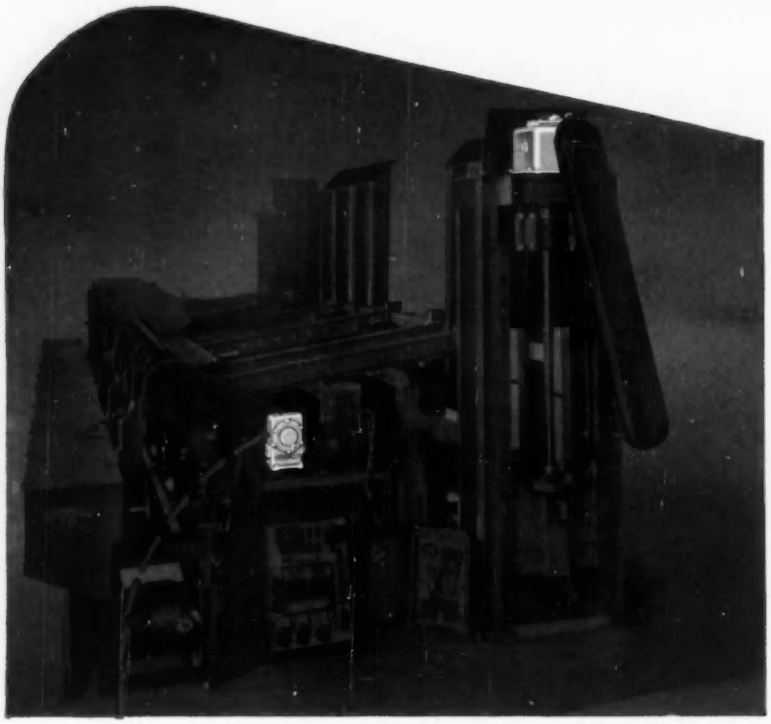
Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN RESEARCH AND DEVELOPMENT

Machines replace humans to serve humans — page 5



Spurgeon Automation Unit on the test floor of the Spurgeon Company at Van Dyke, Mich. Note the vital points where Clevelands are installed—a small unit (20AT) driving the feed mechanism and two 70ND units, one at each end of the elevator lift.

Spurgeon automation unit employs three CLEVELANDS

IN a Detroit automotive plant, three Spurgeon units automatically elevate, transfer and feed steel bars into bar cut-off machines. Top production is gained and hours of man power and money are saved by automation.

Three Cleveland Worm Gear Speed Reducers are employed on each Spurgeon unit: Two vertical reducers on the mechanical drive that operates the elevator; a third Cleveland on the "V" Roll Conveyor pushes the rods into the bar cut-off machine.

Automation and Cleveland Worm Gear Speed Reducers go hand-in-hand. Precision matching of case-hardened steel worms to nickel-bronze gears insures 100% dependability. And, the compact, right-angle Cleveland design saves space and makes installation easy.

Find out what Cleveland can do for your operations before you buy. Catalog 400 gives the story. The Cleveland Worm and Gear Co., 3279 E. 80th St., Cleveland 4, O.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

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Worm Gear
Speed Reducers

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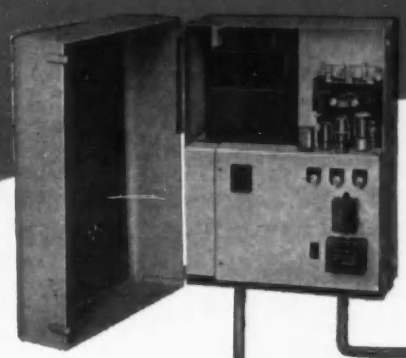

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Elongation, % in 2"	6	5	8	14
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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

NOVEMBER 25, 1957 Vol. 28, No. 21

Aluminum Impact Extrusion— 72 . . . Nicholas Marchak, Sun Tube Corp.
Improved tooling broadens applications of this economical method. Article shows parts can now be made in wider ranges of OD, length, wall thickness.

How to Make Contented Engineers— 75 . . . G. F. Nordenholt
Company executives give their recipes for finding engineers—and keeping them. Survey is by the former chief editor of PRODUCT ENGINEERING.

Instrument Gear Specifications— 80 . . . W. A. Wiegand, Dynamic Gear Co.
Over-fussy requirements eat up time and money. These seven rules will boil down specifications on backlash, tolerances, etc., to a practical minimum.

London Conference on Lubrication— 82 . . . Ernest Rabinowicz and H. A. Hartung
Guest editors report on research papers on lubrication and wear.

Plastic Extrusions— 84 . . . Robert Marx, Anchor Plastics Co.
This review passes on to readers the benefits of latest know-how, such as shrinkage control, in a fabrication field where applications are mushrooming.

Probability and Assembly Fits— 88 . . . G. D. Pheil
When figuring tolerances of parts in an assembly, statistical analysis is tedious —and often unnecessary. Here's how probability curves will reduce labor.

Design Features in New Products— 90 . . .
Tenth-second stop watch; unusual cleaner from usual parts; machine sells at four prices; relay resists vibration; sprag device prevents creep.

Less Noise from Small Engines— 95 . . . Roy Kamo and Frank Iwatsuki
Gasoline engines, both 2- and 4-cycle, can be quieted to acceptable noise levels by applying proved acoustic principles described in this article.

SPECIAL REPORT

Lubricating with Air— 99 . . . Nicholas Chironis, Associate Editor, PRODUCT ENGINEERING
J. S. Ausman and M. Wildmann, North American Aviation
Just why the reawakened interest in air or gas bearings? One reason is their superiority to oil-lubricated bearings in many jet-age applications. This two-part review describes stepped-up research, translates new concepts into practical design charts for hydrodynamic type of gas-lubricated bearing.

DESIGN FILE

Overrunning Clutches—118 . . . W. E. Mulholland, J. L. King, Jr., Formsprag Co.
Illustrated here are 10 ways to put these devices to work.

Stretch-formed Parts—121 . . . Bruce Russell, Chance Vought Aircraft
How to calculate changes that will affect final dimensions of these parts.

DEPARTMENTS

Interesting to Note	5	Catalogs and Bulletins	167
Developments to Watch	9	Design Abstracts	174
Design Perspectives	67	New Books	179
Editorials	71 and 113	Readers' Letters	189
The Engineering Week	107	Press Previews	204
New Components, Materials	125		

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Interesting to Note . . .

Coin Machines—from Holy Water to Coke

From company lunch rooms to subway platforms, office buildings to theaters, America is decorated with vending machines. Be it cigarets, coffee, soup, sandwiches or ice cubes, the vending machine industry is booming. In the last 10 years, sales of its merchandise jumped 280%: from $500 million in 1947 to $1.9 billion in 1956. This year, some 3.2 million machines will sell some $2.3 billion in consumer items. Robert Z. Greene, president of the Rowe Manufacturing Co., thinks that 1956 produced the "breakthrough into a completely new phase" of development, such as inplant feeding and retail food dispensing (See cover–photo at right from Westinghouse, E. Springfield, Mass.). But where did it all begin?

The oldest vending machine on record was designed in 219 B.C. by a Greek high priest, Ctesibus. His machine consisted of a balanced bar which, when a 5-drachma coin fell on it, tipped to open a valve and release a few drops of holy water. When the bar tipped, the coin fell off, allowing the bar to move back into balance and close the valve. The priest found his invention provided revenue as well as aiding his overworked helpers.

Vending machines have come a long way since Ctesibus' time, but as Sam Koppelman, president of Detroit's Automatic Caterers says, "people still like to have a pretty girl hand them a sandwich." However, we will have to get accustomed to the machine—now they even count your change (see page 90).

Engines Were His Hobby

Engineering Shortage? These words are now considered in the realm of the cliche. Yet the engineering journals say "yes," while a few diehards cry "show me." In his article on page 75, George Nordenholt, now-retired editor of *Product Engineering*, says that engineers can be found and kept.

A difficulty in keeping engineers, the chief engineer of a machine tool plant points out, arises from failure to train college grads in proper shop methods. It's easier to train a mechanic to be an engineer than retain the college grad. Some college-graduate specialists work only on problems worthy of their education, training and abilities.

This reminds us of Norman Gilman. His formal education stopped at grammar school. Early in his life, engines became

(Continued on page 7)

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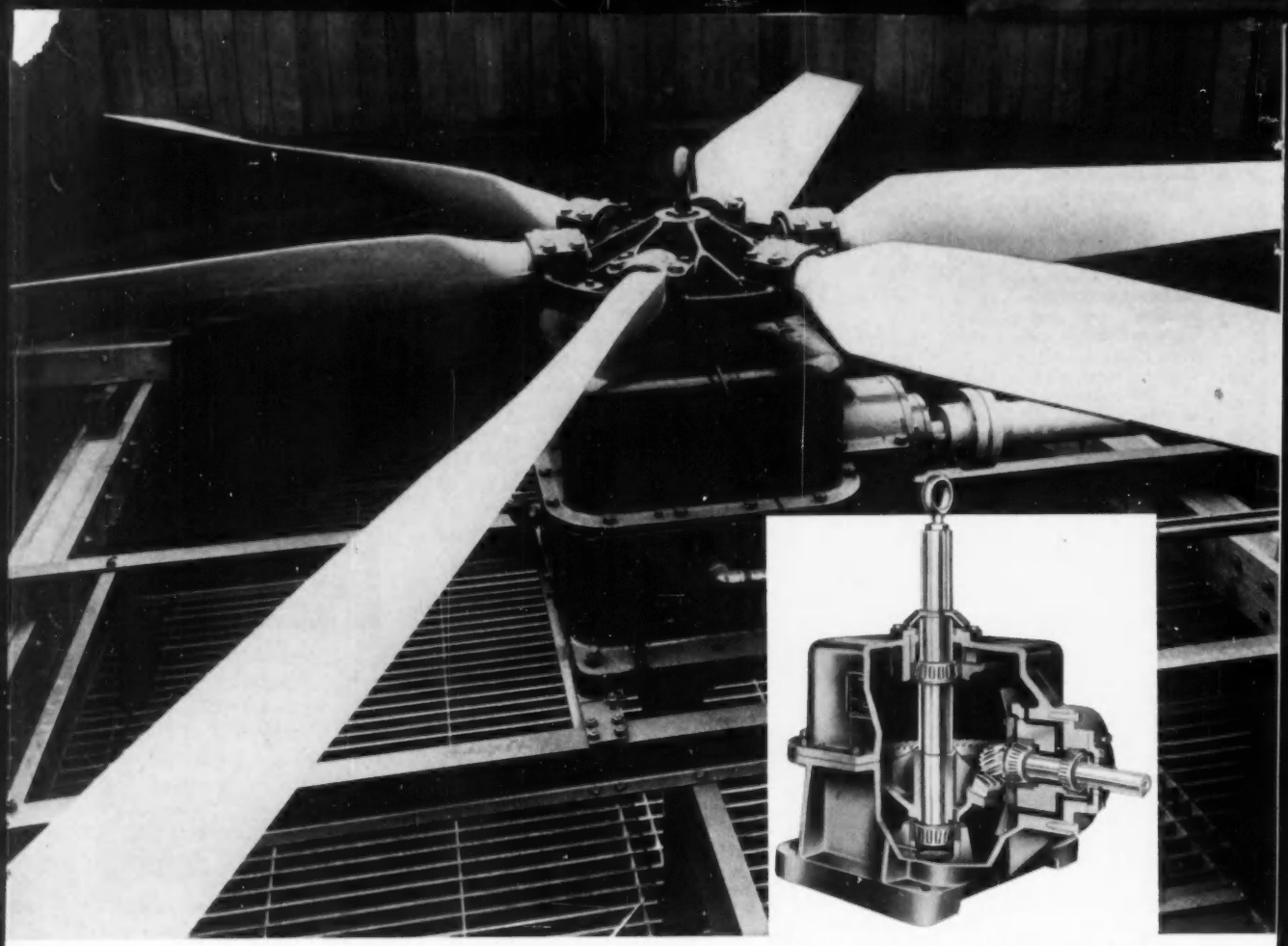

This spiral bevel gear combination permits the flexibility required to meet rugged 24-hour service while providing an economical, self-contained unit which requires practically no maintenance.

How to obtain help when you design bevel gear assemblies

The men who designed the gear reducer for the cooling tower fan shown above were assisted in many ways by Gleason engineers.

Cooling tower fan operation is generally recognized to be one of the most severe tests to which a gear reducer can be subjected. These towers demand a gear system that can operate twenty-four hours a day, three hundred and sixty-five days a year if necessary.

The gear reducer is subject to heavy loads and lies in the path of moist, corrosive air streams.

The gear drives for these cooling tower fans are subject to heavy loads and lie directly in path of moist, corrosive air streams.

Here is what the customer and Gleason engineers developed.

A spiral bevel drive of 19 x 76 combination and 2.5 DP. With spiral bevel gears the tooth bearing is localized which assures smooth and quiet operation and permits some mounting deflections without concentrating the load dangerously near either end of the tooth.

The use of this gear design also allowed the flexibility required to fit the fan unit into the over-all design of the tower and to produce an economical, self-contained unit which requires little or no maintenance.

Next, our engineers produced and tested prototypes of the design which the customer in turn tested in the final product.

Our engineers can also help you select proper mountings for such gear assemblies and advise you on such details as lubrication.

If you would like to take advantage of this service, write us the next time you have a problem involving bevel or hypoid gear systems. Furnish data covering type of application, loads and speeds and prints of the mountings. We would be pleased to assist you in the selection of your gears.

Meanwhile, you may find these Gleason Technical Handbooks helpful in your work:

"20° Straight Bevel Gear System"
"Spiral Bevel Gear System"
"ZEROL Bevel Gear System"

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Builders of bevel gear machinery for over 90 years

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his hobby. As he once said, "By just listening to an engine running I could tell what was the matter with it and how it could be improved." He developed the Allison engine to a high degree of perfection but, "I was able to go just so far. Then I thought of Ronald Hazar, a college-graduate research worker at General Motors. I asked the company to let him take over the design of the Allison engine. He did. We both knew engines but he knew a lot more besides. That's why he was able to bring the Allison engine to perfection so rapidly."

Big Wind from Ohio

Back at the close of the last century, a man in St. Louis had just secured the contract for cleaning out all the railroad cars at the freight depot. This unknown fellow had no experience at this type of work, but reasoned that he only had to blow air through a hose and within a few minutes, the dirt would be blown out of the car. His blower worked fairly well, but after spending several weeks coughing and wheezing in a virtual dust chamber, he reversed procedure and had his mechanism suck the air through the hose. This crude system worked much better and was one of the first industrial vacuum cleaners. (The latest type, pictured on page 92, cleans runways for jet aircraft.)

About 10 years later, Murray Spangler, a janitor in a large Canton, Ohio, department store, found a way to stop stirring up dust from the carpet he was cleaning. He took an electric fan to provide suction, and added a rotating, sweeping brush driven by the fan motor—creating a portable suction sweeper. By attaching his wife's pillow slip behind the fan, he accidentally solved one of the greatest difficulties in vacuum cleaner mechanics—catching the dirt.

Spangler thought his gadget might be commercial, so he took it to some friends who operated a saddlery and harness plant. They became interested and asked their son, a traveling salesman, to try and sell the item. He did and found it very commercial indeed. The father and son manufactured the brush-driven cleaner and an industry was born. Their name—Hoover.

Air for Sale

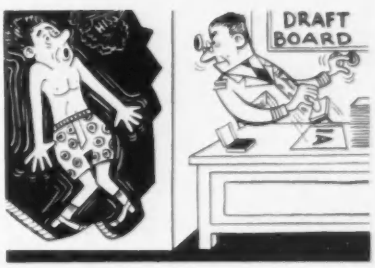
Perhaps the most disastrous display of air power is the typhoon. And never was the force of a typhoon more dramatically imprinted on the pages of history than when the massive fleet of Kublai Khan left China's mainland in 1281 to invade Japan. The small Japanese island would have fallen easy prey to the Golden Horde had it not been for a great typhoon which blew up from the China Sea and practically destroyed the entire force.

The Japanese wind God, *Fujin*, again came to the aid of Japan in mid-December, 1944. When Admiral Halsey's Third Fleet withdrew after attacking Luzon, an intense typhoon came without warning and struck the US fleet. The storm was so violent that three ships were sunk, 22 damaged; 146 planes were blown overboard; 790 lives were lost. This storm, not the Japanese Navy, forced indefinite abandonment of the then-planned American invasion of the Philippines.

Air harnessed as a control for power devices was discussed in the October 14 issue (p. 72), and as a lubricant is treated on page 99 of this issue. Many years ago in Holland, air for powering windmills could only be obtained by purchasing it from a wealthy land baron who claimed the air was his.

This baron prospered a long time—until someone found that his mill went right on working even after he forgot to pay his monthly air bill.

A Hiss in the Dark



With the first Boeing 707 jet being flight-tested prior to delivery to Pan American Airways, we wonder how long the New York Port Authority can continue its ban on "loud jet" aircraft in and around the New York area. The sounds of jets have been called "unbearable" and likened to the artificial wail of a Stuka dive bomber about to unleash its terror. As a psychological weapon, the Germans were experts on the use of sounds–buzz bombs, screaming Mimi. On this side of the ocean, sound was used to catch a draft dodger.

One of the easiest ways for a prospective draftee to have his file stamped 4-F used to be by feigning deafness. There was little a draft board could do if a robust, healthy-looking lad kept saying, "Pardon me, could you speak a little louder?" Certainly, the Army didn't want a soldier with a hearing impediment. But, how do you tell if a person is really deaf or just looking for an easy way out?

If a reasonable doubt existed as to a draftee's hearing facilities, he was ushered into a long, narrow, wooden chamber. It was dark inside except for a slight glow around an overhead red lamp. The subject was told simply to walk through the black chamber while his eyes were being checked for night-vision. As he groped slowly along, a pair of eyes watched him closely. At a certain point within the chamber a hissing sound was produced by a sound-effect record. If the subject reacted by either turning his head towards the sound or by rapidly trying to avoid it—1-A.

This test used sound to advantage. More often, sound is unwanted and becomes noise. How small gas engines are quieted is the subject of an article on page 95.

—Benedict A. Leerburger Jr.

TYPE S*

Adjustable or non-adjustable. Positive-acting, single-stud (shown) or nozzle mounting. Operation to 600°F. Ratings: 15 amps at 115 volts AC, 7 amps at 230 volts AC. Spade or screw type terminals. Bulletin 1000.

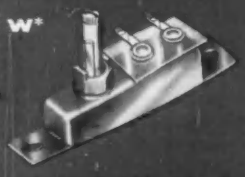
TYPE SA*

Adjustable or non-adjustable. Also Type SM* Manual Reset style. Snap-acting with electrically independent bimetal. Also single-pole, double-throw. Non-inductive-load rating 15 amps at 115 volts AC, 10 amps at 230 volts AC. Spade or screw terminals; single-stud (shown) or nozzle mounting. Bulletin 2000.

TYPE A*

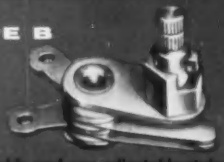
Semi-enclosed and hermetically sealed styles. Insulated, electrically independent bimetal disc gives fast response and quick, snap-action control. Operation from —10° to 300°F or higher on special order. Various mountings and terminals. Rated at 6½ amps at 115 volts AC, 3 amps at 230 volts AC and 28 volts DC. Bulletin 3000.

TYPE W*



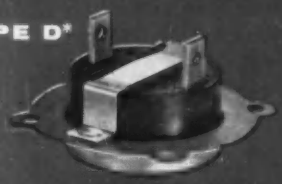
Adjustable and non-adjustable styles. Snap action. Operation to 300°F. Rated at 5 amps at 115 volts AC, 3 amps at 230 volts A.C. Screw, solder and spade terminals. Bulletin 4000.

TYPE B



Adjustable and non-adjustable styles. For applications where heat generated by passage of current through bimetal is desirable. Various terminals; single-stud (shown) or nozzle mounting. Operation to 400°F. Nominal rating: 5½ amps at 115 volts AC of 40 cycles and higher. Bulletin 9000.

TYPE D*



For laundry dryers or other surface and warm air applications. Automatic (shown) and manual reset types. Snap-acting disc type U.L. approved for operation to 300°F. Rated at 25 and 40 amps at 120-240 volts AC. Open or Enclosed styles. Bulletin 8000.

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AA-6294

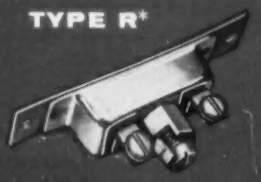
TYPE M*

Semi-enclosed and hermetically sealed styles. Electrically independent bimetal disc type for appliance and apparatus applications from —10° to 300°F. Ratings: 8 amps at 115 volts AC, 4 amps at 230 volts AC and 28 volts DC. Virtually any type terminal. Bulletin 6000.

TYPE H

Positive-acting, adjustable, for fry pans, skillets and other appliances. Full-safe, open in low to 500°F in high. Rated at 1650 watts at 115 volts AC. Bulletin 10,000.

TYPE R*



Adjustable and non-adjustable styles. Positive acting for operation to 600°F. Rated at 15 amps at 115 volts AC, 4 amps at 230 volts AC. Screw terminals. Bulletin 7000.

STEMCO® THERMOSTATS

STEVENS *manufacturing company, inc*
Lexington and Mansfield, Ohio

*Refer to Guide 400 EO for U.L. and C.S.A. approved ratings. Patent Applied For.

Developments to Watch

GRAPHITE FOR MACHINE PARTS?

. . . Horizons, Inc., thinks maybe so. It has a process for coating graphite with carbide which, it says, should make it possible to take advantage of the machinability of graphite, while providing some of the hardness and wear resistance of silicon carbide. Cost is not expected to be high. Coated graphite, says Horizons' Dr. Morris A. Sternberg, might make it possible to replace silicon-carbide die inserts in molds for casting aluminum and copper alloys, furnace fixtures, and nuclear reactor parts. Other applications remain to be explored.

COATINGS THAT ARE TOUGHER, MORE FLEXIBLE . . .

. . . and better able to resist alkalis are coming from the General Mills Research Laboratories. They're mixtures of phenolic resins with GM's Versamid polyamide (nylon-type) compounds; and GM believes they combine most of the best features of both—hardness and heat resistance of the phenolics with flexibility of the polyamides. The coatings are said to resist food oils, aliphatic hydrocarbons, and solvents like toluene and oleic acid, but GM admits there is "some decrease in resistance to water, the lower alcohols, and acetone."

SIZE RESTRICTIONS CAN BE REMOVED . . .

. . . from vacuum-cast parts if a new process now under test at US Steel's Duquesne Works proves out. Vacuum castings weighing nearly 2000 tons, and 95 in. in dia., are being made, and USS says their quality seems excellent. The castings are more ductile than those produced by conventional methods, and the metal less sensitive to rupture.

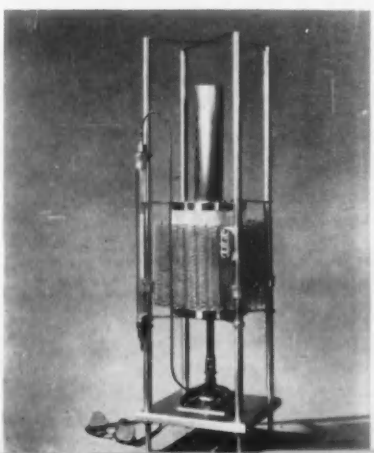
GAS BURNERS FOR ELECTRIC POWER? . . .

. . . Bell Labs thinks it's a possibility, particularly when power requirements are low and long-time unattended operation is required. BTL engineers are now working on thermoelectric generators which can be installed in telephone poles to provide power for telephone relays in remote areas. The pole itself can serve as a fuel tank, and woven thermocouple mats, made of such materials as chromel-p and constantan, convert the heat into electricity.

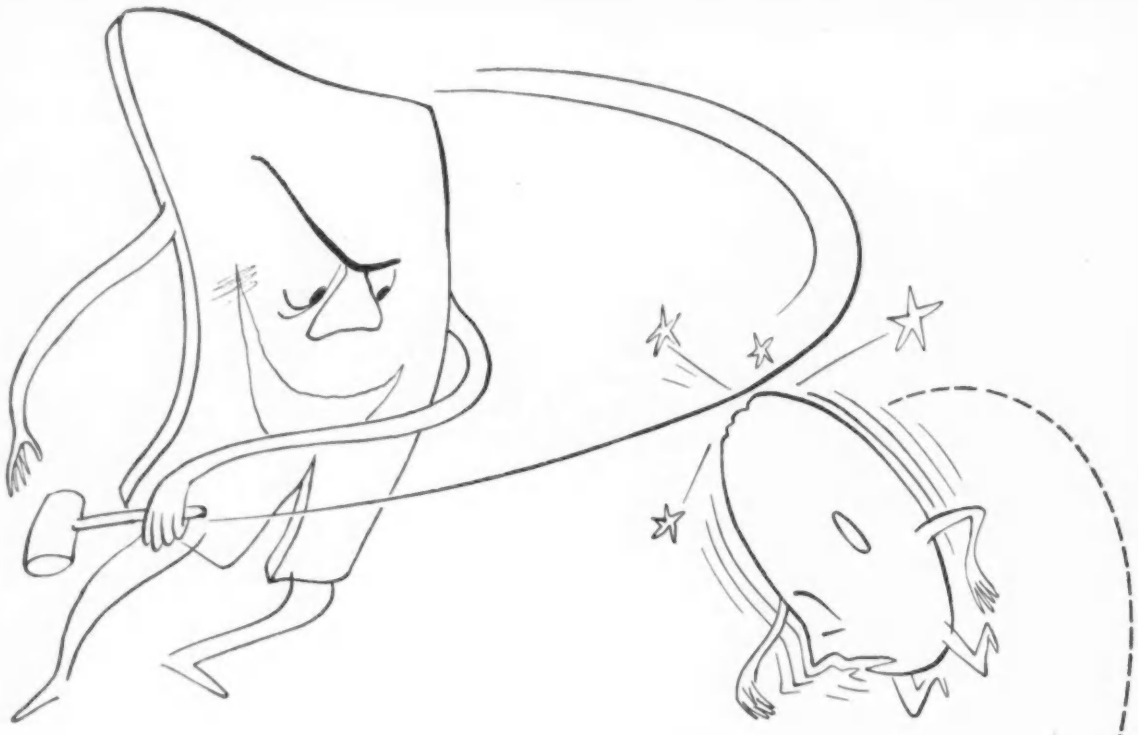
An example is the device pictured below, which produces 1.25 w at 25 v. Fuel requirements are amazingly low. Bell Labs says "the heat required is only a little more than that produced by an ordinary candle." Other advantages: There are no moving parts, operation is noise-free, no electrical storage is needed. However, burner design is extremely important (all fuel must be consumed without need for excess air, and heat must be distributed properly along the hot junctions).

(Another novel power source was described in the Nov. 4 issue, p. 5.)

Thermoelectric heater . . . mounted in telephone pole (right), supplies power for rural carrier system. Device is still experimental, but Bell Labs believes it can be put to practical use.



—A. R. G.

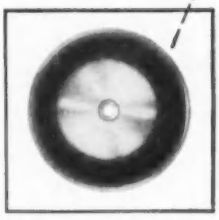


No matter how they sliced it, RUBBER dulled their SKIVING KNIVES

The skiving knives used by a rubber processor had a short service life because rubber is highly abrasive. The disk-shaped blades had to be re-sharpened after each working shift, resulting in costly down time.

By Flame-Plating the knives on one side with tungsten carbide, their service life was increased 15-fold. Also, the knives gained the advantage of a self-sharpening effect: as the uncoated steel side wears more rapidly than the coated side, a sharp edge is always presented to the material being cut.

Flame-Plating is LINDE's special process for coating metals with a very hard and durable surface. By this method, tiny particles of tungsten carbide or aluminum oxide are literally *blasted* onto almost any metal surface. Most important, the temperature of the part seldom exceeds 400-degrees F., so there is little or no chance of changes in the shape or metallurgical properties of the part being coated. Flame-Plated coatings can be applied from .010 to .002 inches thick, and finished to 0.5 microinches rms.



The machinery and equipment you use to fabricate rubber can have its service life greatly extended at critical points of wear by Flame-Plating. For more information, write for a free copy of the booklet, "Flame-Plating," F8065. Address Flame-Plating Dept., LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

UNION CARBIDE

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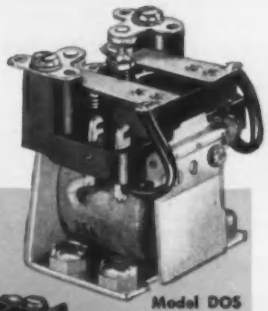
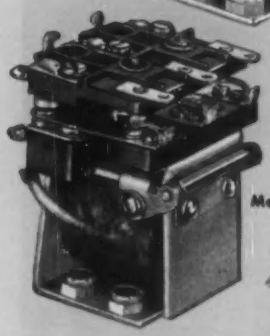
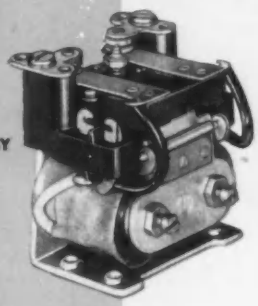
specify OHMITE® relays where dependability is a must!



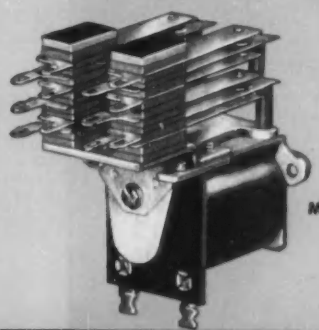
Model DOS



Model DO



Model DOSY



Model CRU

65 types in four stock models . . .

OHMITE RELAYS provide the same traditional dependability that electronic engineers in industry have come to expect of Ohmite components. Ohmite all-purpose relays have proved their exceptional ruggedness and long life in years of service. Four popular stock models—DOS, DOSY, DO, and CRU, in 65 different types, are available. Models DO and DOS fill many industrial needs for a compact, lightweight relay that handles power loads usually requiring much larger, heavier units. They are particularly adaptable to aircraft and mobile equipment where severe shock and vibration are encountered. The increased operating sensitivity of Model DOSY relay, equipped with twin coils, makes the DOSY adaptable to a wide range of electronic control circuits, such as plate circuit controls. At 115 VAC or 32 VDC, noninductive load, Models DOS and DOSY have contact ratings of 15 amp; Model DO, 10 amp; and Model CRU, 5 amp. Available in a wide range of coil operating voltages and contact combinations.

countless variations in made-to-order models

In addition to the four stock models in 65 types mentioned above, Ohmite has seven standard types of relays available promptly made to order. These units are available in many contact combinations and coil voltages. They are also available in hermetically sealed or dust-protective enclosures. Ohmite engineers will be happy to make a recommendation designed to meet your needs.

SEND FOR CATALOG R-11

BE RIGHT WITH

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RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES
TANTALUM CAPACITORS • VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3611 Howard Street, Skokie, Illinois

Why designers specify FLEXLOC self-locking nuts

Where products must be tough . . . must stand up under vibration, shock and abuse . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts as fasteners.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

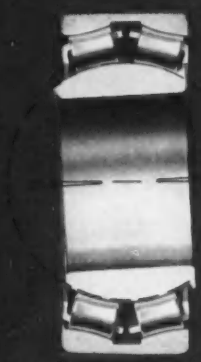
FLEXLOC® LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

self-aligning . . . CAN'T BIND



HOW SELF-ALIGNMENT WORKS. Spherical inner ring, free to align in any direction, assures full load capacity regardless of shaft deflection or support misalignment.

Husky bearings in husky housings adjust immediately in any direction

When high-impact loads deal out punishment, shaft deflection may spell a quick finish for ordinary bearings. But this rugged Link-Belt bearing is *self*-aligning . . . won't "pinch" or bind when misaligned.

Complete protection is provided by effective seals which block entrance of dirt, escape of lubricant. Durable housing—machined as two perfectly matched parts provides easy installation without shims or alignment rings.

Get full data on Link-Belt's complete bearing line from Book 2550. Ask any of 40 offices.

Series 6800, 6900, 7800, 7900 roller bearings have internationally standardized boundary dimensions.

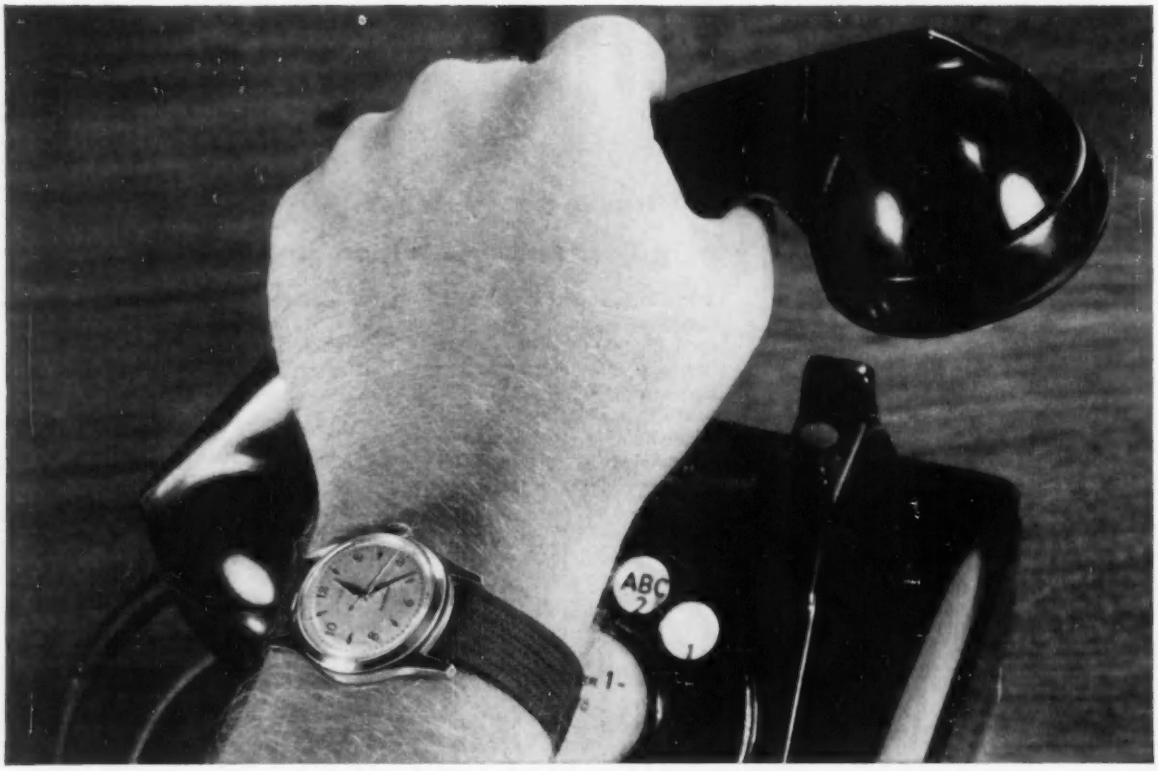
LINK BELT

self-aligning ball and roller bearings

14,441-A

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

NEED HOLLOW PARTS STOCK FAST?



We ship less-than-mill quantities of TIMKEN® 52100 steel tubing in less than 24 hours

SPECIFY any of the 101 sizes we stock, and your Timken® 52100 steel tubing will be on its way within 24 hours of the time we receive your order. You can select O.D.'s ranging from 1″ to 10½″, and a variety of wall thicknesses. Meet your schedules with our mill stock and save time.

And you can save both time and money when you substitute Timken 52100 steel tubing for more expensive steels. Because it's through-hardenable in moderate sections, you can heat treat it to file hardness, or temper it back to meet your needs. You can depend on uniformity from tube to tube, heat to heat, and order to order.

That's why Timken 52100 steel is so widely used for so many things—aircraft engine parts, ball bearing races, pump parts and plungers, collets, bushings, spindles, grinding machine parts, precision instruments and dozens of other uses.

We pioneered in producing 52100 tubing in America, and we're the only company making this steel in all three common forms: tubing, bars and wire. So call, wire or write your order to The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

It's a tough life

but the sensitive

Fenwal THERMOSWITCH® unit takes it in its stride

Fenwal THERMOSWITCH Temperature Controls are enclosed in a tamper-proof assembly that's built to take grueling punishment — and stay highly accurate, uniformly sensitive throughout the operating range — *and its range is three to five times that of an ordinary thermostat!*

That means you can run your machine at greater speeds . . . your machine will require less maintenance! It means greater flexibility for your machine — greater sales for you — *and all at a low first cost.*

Even the assembly of a Fenwal THERMOSWITCH unit is easier and cheaper! The application of Fenwal THERMOSWITCH units are limitless — they're being used in planes . . . factories . . . ships . . . hospitals . . . homes . . . laboratories — *used almost any place where temperature is a factor and accuracy is a must!*

Drop us a line at Fenwal Incorporated, 214 Pleasant Street, Ashland, Mass. and we'll send you our catalog MC-135 or our sales engineer, whichever you want.

This is our 17000 series (we've got 25,000 other variations with the operating ranges from –100°F to 600°F) in use in Master Jet Frymaster. The Fenwal control gives the machine rapid, precise response; greater reliability — even makes it more economical by conserving cooking fat and gas!

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

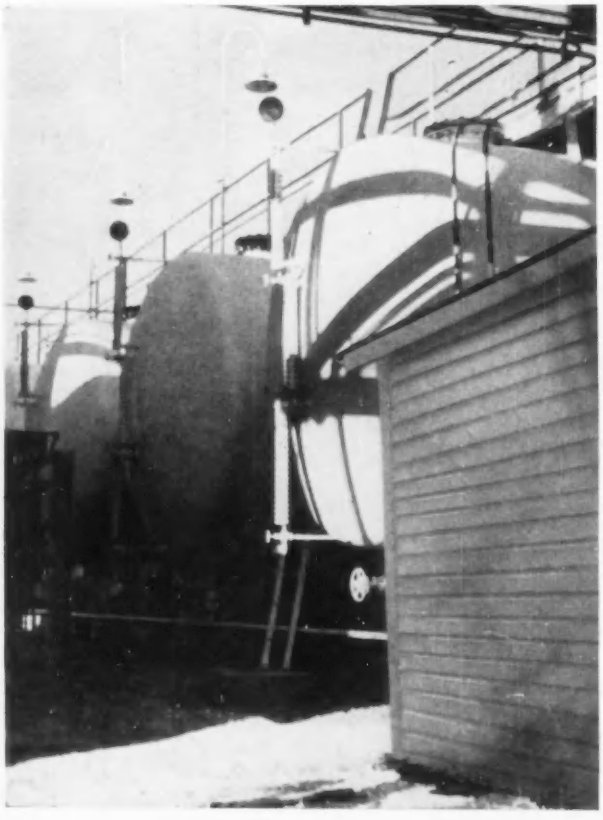
Designing with BAKELITE BRAND Plastics

- ***Coating protecting tanks for 3 years***
- ***Rugged plastic part for carburetor air cleaner***
- ***Plastic credit cards that print***

Keep informed about plastics and you'll find them a source of new design ideas. Besides the great variety of plastics already available, new products are constantly appearing. One of them may have exactly the set of properties you have been looking for, and at a considerable saving.

Keep in touch with Bakelite Company. It is your best source of information because it is a leading source of plastics. You can select from the widest variety of materials in the field – phenolics, vinyls, styrenes, impact styrenes, polyethylenes, epoxies, and silicones. And you can call on the laboratory services and technical resources of Bakelite Company for aid in working them into your plans.

1 Vinyl-based coating protects ammonia tanks three times longer



Service conditions surrounding these tanks proved too severe for two earlier coating systems – one failed in eight months, the other in a year. Measuring 10' 6" in diameter and 53' long, the tanks hold caustic solution, and are located in a plant manufacturing 45 million lbs. of petrol-cracking catalyst annually. Vapors in the area contain sulfate salts and intermittent sulfuric acid spray.

Three years ago, a coating system made by Amercoat Corp. based on BAKELITE Brand Vinyl Resins was applied to the exterior of these tanks. It has remained in excellent condition. The first coat was worked into the bare metal by brush to obtain good adhesion. Three subsequent coats were applied by spray. Each was a different color to insure complete coverage. Total thickness was six to eight mils. Maintenance has been at a minimum.

A variety of coatings are formulated from BAKELITE Vinyl Resins and used widely in both industrial and consumer applications. For a complete description of these materials, write Dept. AV-145.

2 C-11 Plastic pre-cleaner withstands engine oil, heat, dirt

More than 75 percent of the dirt that would normally enter the oil-washed air cleaner on tractor engines is removed by this collector pre-cleaner made by Minnesota Plastics Corporation for Donaldson Company, Inc., St. Paul, Minn. It is also designed to serve as an air stack cap, preventing leaves, twigs, and chaff from entering, and forms a rain shield that keeps water out of the center tube intake. Molded of BAKELITE Brand C-11 Plastic, this collector pre-cleaner has a high heat distortion point, and stands up under the working temperatures generated by tractor engines. Since C-11 Plastic is transparent, the pre-cleaner shows when it has collected excess dirt, and is readily removed and washed.

BAKELITE C-11 Plastic is an acrylonitrile-styrene copolymer. It has good resistance to impact and exceptional resistance to chemicals, including foods. It offers a wide choice of color, and molds to a smooth, glossy finish. These properties have led to the wide use of C-11 in packaging as well as for machine parts like this collector pre-cleaner. For more details on C-11 Plastic, write Dept. AW-145.

3 Credit card, charge plate, and ad on one vinyl rigid sheet

This wallet-sized plastic card can tell you a lot about the design features of BAKELITE Brand Rigid Vinyl Sheets. The color printing, in perfect register, makes it an effective ad and proves its dimensional stability. The three-dimensional lettering shows how well these sheets can be formed to fine details. And toughness is demonstrated in the card's ability to stamp its imprint on invoices, as well as to take frequent handling without damage.

BAKELITE Rigid Vinyl Sheets come in several stock sizes and finishes, and a variety of colors, as well as clear transparent, translucent, or opaque. They can be formed into three-dimensional shapes to fill a wide range of design requirements. To learn more about them, write Dept. AX-145.

TYPICAL PROPERTIES OF "BAKELITE" RIGID VINYL SHEETS

Heat distortion temp. at 264 psi. Fiber stress, deg. C. (D648-45T)	64 avg.
Flammability (D568-43)	self-extinguishing
Tensile strength, psi (D638-49T)	7700 avg.
Flexural strength, psi (D790-49T)	12,600 avg.
Modulus of elasticity in flexure, psi (D790-49T)	430,000 avg.
Impact resistance (impactometer method) ft./sec. (WC-68-C-1/1) (corrected to .010 inch)	55 avg.
Specific gravity, 23/23 deg. C. (WC-1-M/1)	1.45 avg.
Dielectric strength (0.100 in. specimen) volts/mil Short time test in oil (D149-55T)	425 avg.
Volume resistivity, ohm-cm. (D257-54T)	10^{16} avg.

THERE'S MORE TO DESIGN WITH IN

BAKELITE
BRAND
PLASTICS

PHENOLICS
STYRENES
IMPACT STYRENES
VINYLS
EPOXIES
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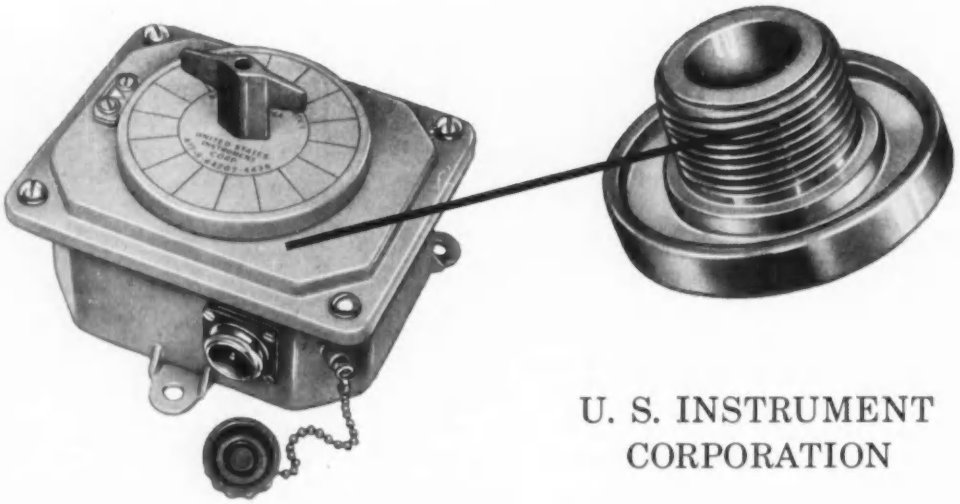
Three more nationally known manufacturers select Mueller Brass Co. Forgeable Bearing Alloys for vital components of their products

In ever-increasing numbers, Mueller Brass Co. specialized alloys are being specified by manufacturers of top-quality products. In a series of continuing advertisements, we have presented case histories of successful applications, to which we now add three more distinguished companies who are incorporating Mueller Brass Co. forgeable bearing alloys in their products to meet the demands of widely divergent operating conditions.



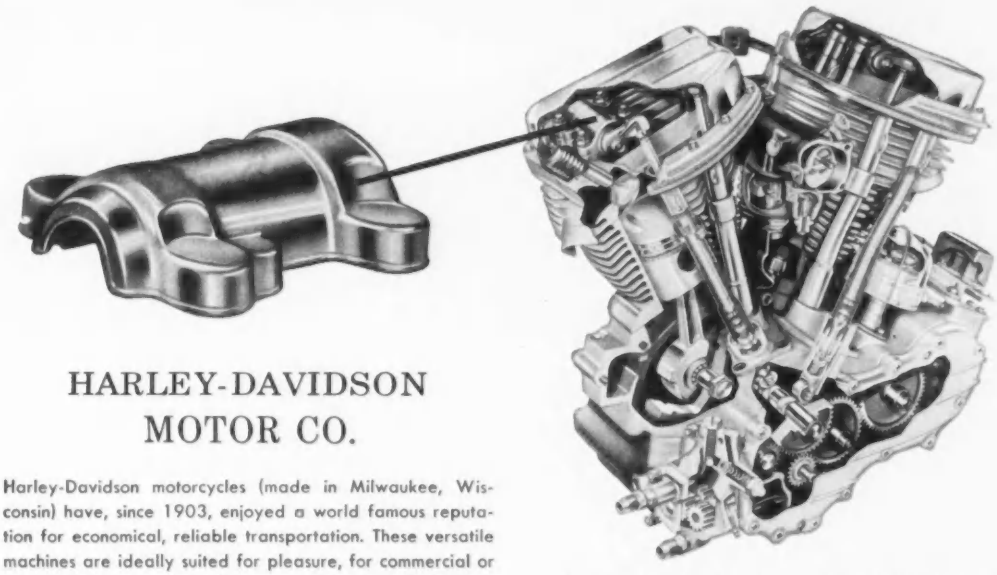
U. S. INSTRUMENT CORPORATION

U. S. Instrument Corporation, Charlottesville, Va., selected abrasive-resistant Mueller bronze alloy bushings for their remarkable telephone selector switches after exhaustive tests of many materials. A vital communications link on today's U. S. Naval vessels, these sound-powered telephone circuits must meet rigid Navy performance-standards. Such phones, for example, must have selector switches which are capable of rotating for a minimum of 50,000 torturous cycles . . . 360° clockwise, followed by 360° counter-clockwise. In addition, the "O" ring must still form a water-tight seal AT THE END OF THE TEST! Of the many tested, a Mueller Brass Co. special manganese bronze alloy was the best one meeting these rigid specifications.

There were other important reasons why these bushings were chosen by U. S. Instrument Corporation for this application. Resistance to abrasive action against the rubber "O" ring was a prime one . . . then, too, the stem assembly suffered severe pounding through the action of the indexing mechanism which, prior to the use of the Mueller Brass Co. alloy, caused repeated seizure of the component parts. In this particular application, the part was fabricated on an automatic screw machine rather than produced as a forging. The versatility of Mueller Brass Co. alloys makes them readily adaptable to the most economical method of fabrication dependent upon the size, shape, and end-use requirements of the part.

In commenting on the success of this part, U. S. Instrument Corporation praised the alloy for its tensile strength (ordinary brasses could not withstand the 2000 ft. lb. impacts without deformation), for its machinability and corrosion-resistance.

MUELLER BRASS CO.



HARLEY-DAVIDSON MOTOR CO.

Harley-Davidson motorcycles (made in Milwaukee, Wisconsin) have, since 1903, enjoyed a world famous reputation for economical, reliable transportation. These versatile machines are ideally suited for pleasure, for commercial or business use, as well as the grueling demands of law enforcement work. Harley-Davidsons boast a dependable engine . . . one which can roll up an astounding mileage record with little or no care. The painstaking selection of every engine component is one important reason for this reliability. The new twin-cylinder Harley-Davidson 74 OHV employs Mueller Brass Co. bronze alloy forgings in the form of rocker-arm bearing caps. Subjected to violent temperature changes, fast starts and stops and road shock, Mueller forgings are proving again and again that they have the ability necessary to withstand almost any punishment . . . and still provide unfailing service.

JACOBSEN MFG. CO.

Jacobsen Mfg. Co., Racine, Wisconsin, was among the first to produce a practical power mower for home use. That was more than 35 years ago! Today, Jacobsen power-mower dependability is evident itself in more than a dozen gleaming new models such as the popular Pacer, Lawn Queen, Manor and others. One of the most reliable components in the always dependable Jacobsen hi-torque engine is a Mueller Brass Co. connecting rod forged from special bronze alloy. Jacobsen mowers with Mueller-forged connecting rods are called upon by some commercial users to operate as much as 8 hours daily, 6 days a week . . . perhaps as much as 2000 hours a year. In searing summer temperatures, thru hours of constant operation, the high uniform strength of Mueller bronze forgings constantly withstands pounding and vibration with the same conspicuous success as in its many other applications.

Why not investigate these specialized alloys for your own products. We welcome your inquiries. Our engineering staff will be happy to make specific recommendations. Both on the proper alloy and the best method of fabrication to meet your needs . . . exactly. Our engineering manuals show many, many examples of how American manufacturers have used these alloys to great advantage.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

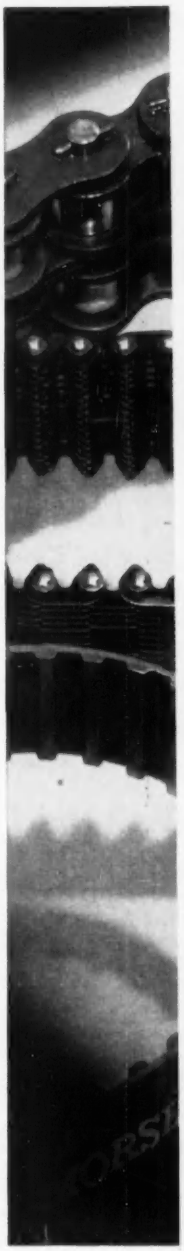
- **Mueller Brass Co. Forgings** Engineering Manual H-58565 ☐
- **Tuf Stuf Aluminum Bronze Alloys** Engineering Manual H-58563 ☐
- **"600" Series Bearing Alloys** Engineering Manual FM-3000 ☐
- **Copper Base Alloys in Rod Form** Engineering Manual FM-3010 ☐

227

PORT HURON 22, MICHIGAN

Here's what Morse's entry into the "Timing"® Belt field means to you...

Nobody gives you a more impartial analysis of your power transmission problems than Morse, because . . . *only Morse* offers all four of these basic drives plus a complete line of power transmission products



Basic Drives: Roller Chain, Silent Chain, Hy-Vo Drives and "Timing" Belt.

Chain: H-E, 8-series, Double-Pitch, Implement, and Attachment; AL, BL, and Rollerless Lift Chain; Industrial Standard and 3/16″-pitch Silent Chain.

Stock Sprockets: Plain Bore, Finished Bore, Taper-Lock—also made to order.

Couplings: Flexible Roller Chain Couplings, Flexible Silent Chain Couplings, Morflex Couplings, Morflex Radial Couplings, Marine Couplings.

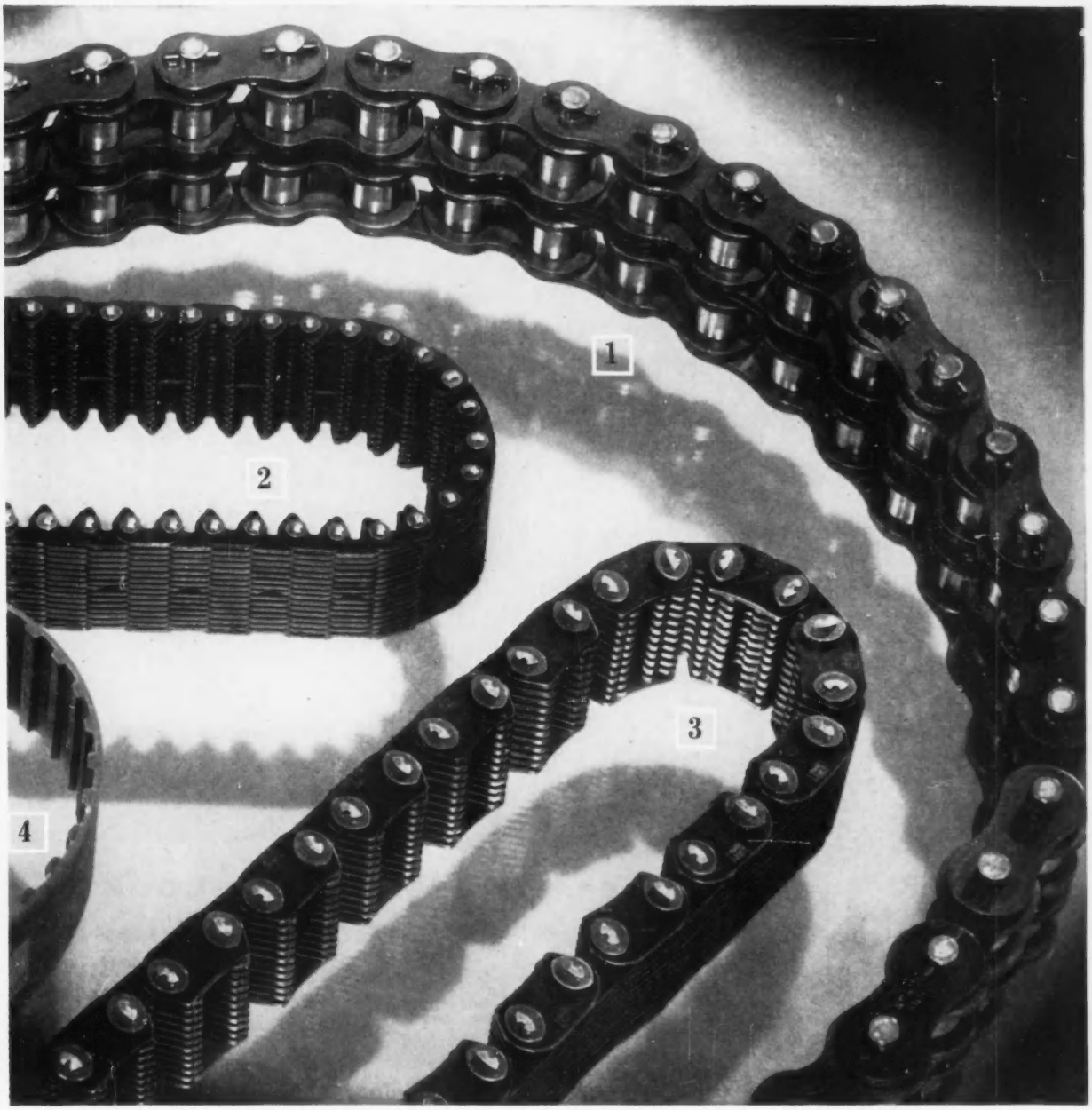
Driveshafts: Morflex and Radial Driveshafts.

Clutches: Overrunning Clutches; Over-Center Clutches.

Speed Reducers: Eberhardt-Denver "RW" poweR-gear® Reducers; Gearmotors; "L" Worm Gear Reducers; "VX" and "DVX" Conveyor Drives; Miter Boxes; Helical Reducers.

Torque Limiters.

Look for your local Morse distributor in the Yellow Pages under "Power Transmission," or write: *MORSE CHAIN COMPANY, DEPT. 4-117, ITHACA, NEW YORK; Export Sales: Borg-Warner International, Chicago 3, Illinois.*



1. **Roller Chain** . . . for low and medium speed applications. Precision-finished Morse Roller Chain is specially treated to withstand shock and fatigue, assure less maintenance, longer service life. Patented Spirol Pin Fastener construction.

2. **Silent Chain** . . . for smoother, quieter operation at higher speeds. In Morse Silent Chain the patented rocker joint operates with less friction and wear. It provides a cooler-running chain drive, with higher efficiency and longer service life.

3. **Hy-Vo Drive** . . . for extremely high speeds and horsepower. Exclusive with Morse, extra-tough Hy-Vo Drives transmit mile-a-minute speeds, and up to 5,000 hp loads; require minimum shaft space, usually eliminate outboard bearings.

4. **"Timing" Belt** . . . for light weight and lubrication-free operation. Morse "Timing" Belts give positive, high-efficiency transmission from 0 to 16,000 FPM, 1/100 HP to 1,000 HP . . . provide slip- and stretch-proof service for life of drive.

IN POWER TRANSMISSION
THE TOUGH JOBS COME TO

MORSE

MORSE B-W BORG-WARNER *

*Trademark

Now! Two Great

ALL-NEW HAMILTON

"L" CONTOUR

FROM

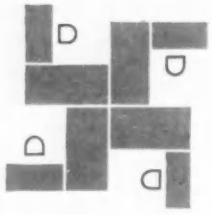
A Great "New-Look" in Drafting Tables!

Here is a dramatic new concept in drafting tables that brings *new reference convenience, new personalized working space, new smartness of surroundings* to modern engineers and draftsmen!

The unique "L" contour allows quick, comfortable movement between drawing board and reference desk. The desk-high, fully adjustable drawing board insures efficient, comfortable working positions. It can be adjusted to any angle from horizontal to vertical, has a 20" vertical adjustment. It automatically locks at 35° from vertical until released manually. An angle sensing device provides complete counterbalancing action.

The versatility of the "L" contour table lends itself to efficient room layouts. The reference desk can be changed to right hand or left hand. The entire unit takes only 60" x 71" floor space.

Now, at last, you can give your engineers and draftsmen efficient, smart-looking, "private office" working areas—achieve a higher degree of morale—with an installation of new "L" contour tables. Take this opportunity to get full information by mailing the coupon at the right.



Here is one of the many arrangements you can make with versatile "L" contour tables to meet any specific requirement you might have.

Whether it's the newest in drafting room furniture or drawing pencils, you can get it from Bruning. There's a Bruning branch office near you. Why not make it your one convenient source for everything you need in drafting and reproduction?

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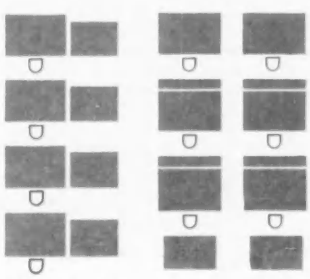

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How Separable Race Roller Bearings with Interchangeable Parts can Improve Machine Design...

With HYATTS, the designer can increase shaft diameter or reduce housing bore by omitting races... eliminate selective fitting for greater flexibility of assembly operations

The unique advantages of straight cylindrical roller bearings which result directly from the geometry of the bearing itself are quite generally accepted by design engineers. They recognize, for example, that cylindrical roller bearings provide greater radial load-carrying capacity because of the larger area of contact between races and rollers. Most designers are also aware that straight cylindrical roller bearings offer the lowest roller bearing friction characteristics because this type most closely approaches true rolling action.

However, a well-designed line of roller bearings provides additional advantages which are not inherent in the bearing geometry, but result from the engineering know-how of the manufacturer. These benefits are not so widely known and are sometimes overlooked by designers.

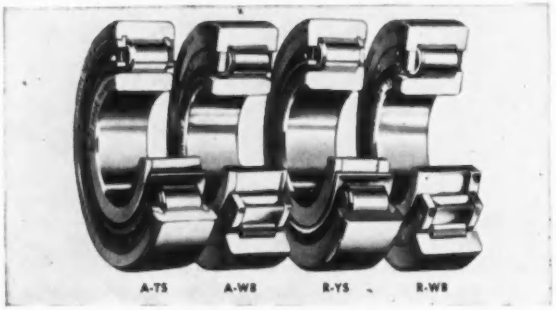
1. INTERCHANGEABLE PARTS PERMIT MORE FLEXIBLE ASSEMBLY

A good example of these "built-in" benefits is the interchangeability of separable bearing parts provided in the HYATT line of cylindrical bearings. Any HYATT Hy-Load Series separable inner race, for a given piece number, can be assembled with any HYATT outer race and roller assembly of the same piece number. Only under special circumstances is there any necessity for selectively matching separable parts of HYATT Hy-Roll Bearings.

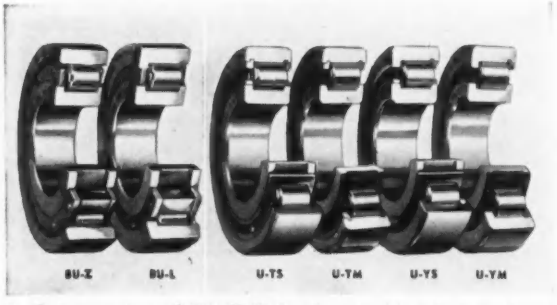
Because of this interchangeability feature, it is practical to install separable HYATT inner races on shafts in one location while the outer races and rollers are installed in housings at another location. When the sub-assemblies are brought together the bearing parts will match perfectly; there is seldom any need for selective assembly. This flexibility of any assembly operation in which selective fitting is eliminated can often be a determining factor in bearing selection.

2. SEPARABLE INNER RACES PERMIT INCREASED SHAFT DIAMETERS

Another advantage of HYATT separable bearings becomes evident when the designer wishes to use a larger, more rigid shaft without increasing the size of the housing bore. He can neatly solve the problem by eliminating the inner race of one of the bearing types shown in Figs. A and D, and operating the bearing rollers directly on the suitably hardened and ground shaft. The space usually occupied by the inner race then becomes available for a shaft of larger diameter.



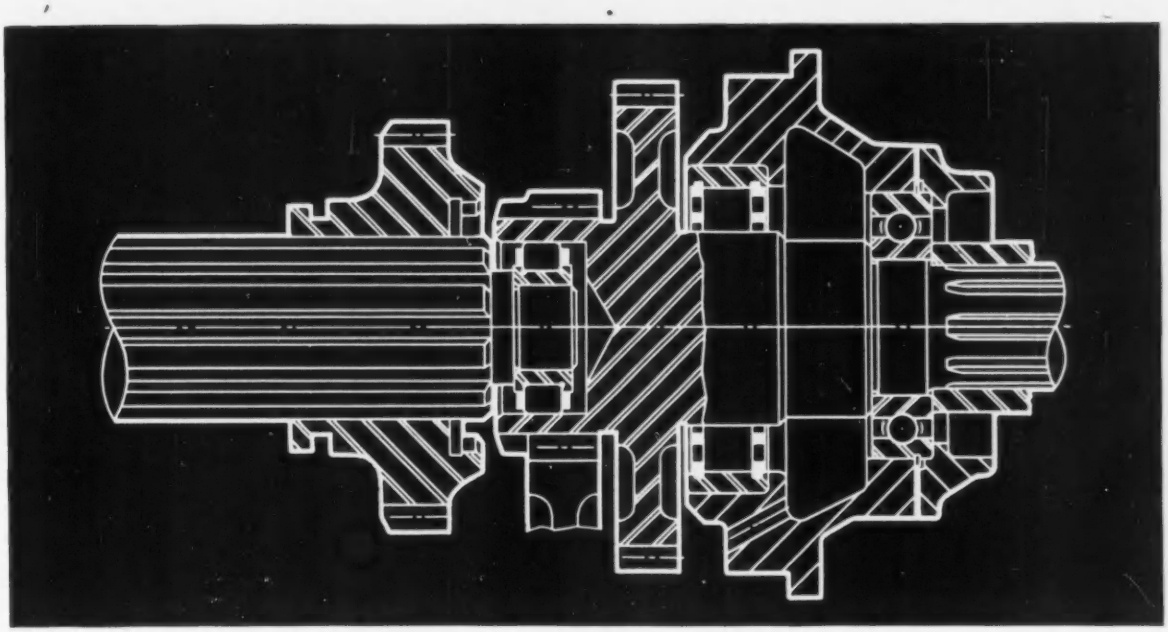
A. Cutaway views of HYATT Hy-Load separable inner race types



B. Cutaway views of HYATT Hy-Load separable outer race types
B-1. Cutaway views of HYATT Hy-Load non-separable types *(right)*

3. SEPARABLE OUTER RACES PERMIT REDUCED HOUSING BORE SIZES

Conversely, when space limitations or other considerations make it necessary to reduce the size of the housing bore without decreasing shaft diameter, HYATT separable bearings are again the answer. In this case, the designer merely eliminates the outer race of one of the bearing types shown in Figs. B and E, and operates the rollers directly on the suitably hardened and ground bore, thus saving the space normally occupied by the outer race. Of course, in applications where it is preferable to retain the bearing parts as a unit, HYATTS are available in non-separable assemblies (Figs. B-1 and F).

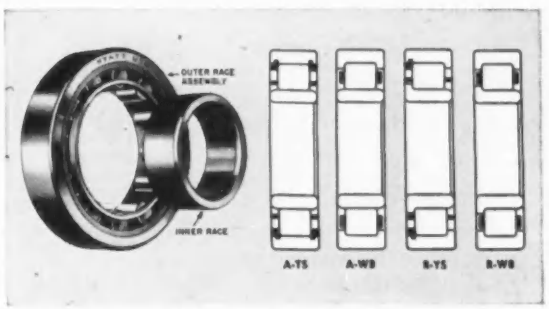


C. Typical transmission application: pilot bearing is BU-Z type without *outer* race, operating directly on hardened and ground gear bore. The A-TS type is used without *inner* race, and operates directly on hardened and ground surface of gear hub.

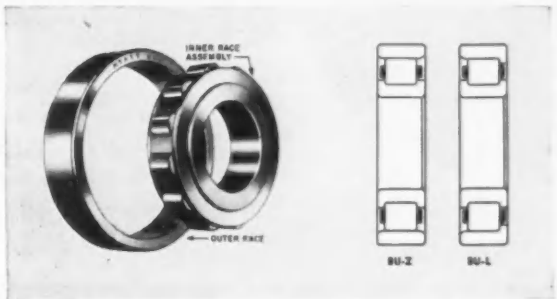
Worthwhile opportunities for improvements such as these in machine design may be overlooked unless designers are familiar with not only the inherent but also the "engineered-in" features of cylindrical roller bearings. So when specifying bearings, it pays to look beyond the life, load, speed relationship and study the relative *installation, sealing, retainment, assembly* and *maintenance* requirements of each individual bearing application.

If you would like to review some of your bearing applications in order to gain an overall production or performance advantage for your product, why not pick up your telephone and call your nearest HYATT Sales Office. For your convenience, telephone numbers are listed below—and the best roller bearing application engineers in the business are at the other end of your line.

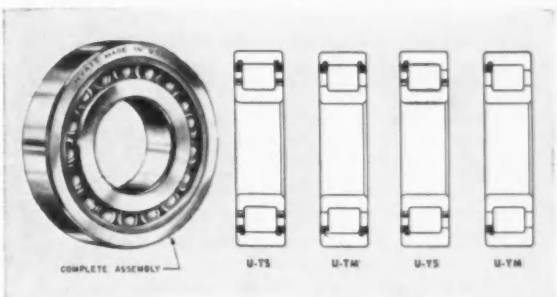
HARRISON, N. J.	**CHICAGO**	**PITTSBURGH**
HUmboldt 4-4000	**HArrison 7-8277**	**ATlantic 1-2927**
DETROIT	**OAKLAND, CALIF.**	
TRinity 2-5600	**TWin Oaks 3-5362**	



D. Perspective and diagrams of separable inner race types



E. Perspective and diagrams of separable outer race types



F. Perspective and diagrams of non-separable types

HYATT BEARINGS DIVISION,
GENERAL MOTORS CORPORATION,
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THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

GM FORWARD FROM FIFTY

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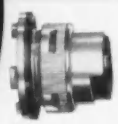
Square D FOR THE MOST COMPLETE line of Oil-Tight

PUSHBUTTONS

Square D pushbuttons, designed to JIC and NMTBA standards, have been proven by severe tests involving millions of operations. They offer still other features... generous wiring space and exclusive *"Slide and Swing"* enclosure covers for easier, faster installations when machine operations are changed.

OIL-TIGHT OPERATORS



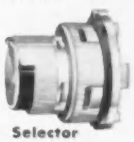
Momentary Contact Guarded button in 7 colors.

Mushroom Button 1⅜" or 2¼". Momentary contact. 7 different colors.

Selector Switch 2 or 3 position with 4 different cams.

Coin-operated Selector Switch Available in same selection as standard type.

Key-operated Selector Switch Discourages unauthorized operation.



Selector Pushbutton combines selector switch and pushbutton. 2 or 3 position.

Padlock Attachment Latch type. For momentary contact buttons. Locks "OFF" position.

Padlock Attachment Covertype. Prevents depressing button.

Maintained Contact Attachment Used with 2 operators, 1 contact block.

Selector Switch Lockout Permits switch to be locked in any one of three positions.

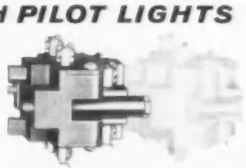
Wobble Stick Operator for momentary pushbutton operator. Ideal for emergency stop with pendant station.

Neoprene Cap for momentary contact button. Prevents liquids, dust and grit from working into pushbutton operator.

CONTACT BLOCKS and PILOT LIGHTS

Single Pole N.O. and N.C. Contacts

Duplex N.O. and N. C. Contacts



Tandem Operation. Duplex N.O. and N.C. Contacts with extended stems for combination with another block.

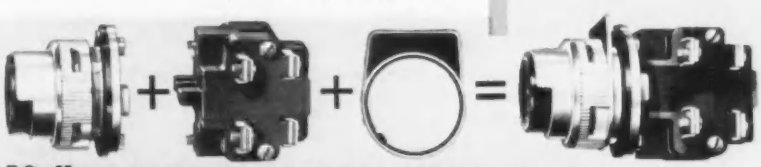
Duplex N.O. and N.C. Contacts with one N.O. circuit closing ahead of the other. Designed for 2-speed or sequence operations.

PILOT LIGHT • Generous illumination and wide-angle visibility. Greatly reduced filament burn-outs. No loosening of lamp under vibration. Six colors—red, amber, green, blue, white, clear.

You'll like the *completeness* of Square D's pushbutton line. Every conceivable combination can be obtained with a minimum stock of packaged units. Enclosures available for 1 to 16 units.

Write for Pushbutton Bulletins which give complete details. Address Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin.

ANY OPERATOR WITH ANY CONTACT BLOCK



NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!

SQUARE D COMPANY

LONGER SOLENOID LIFE...

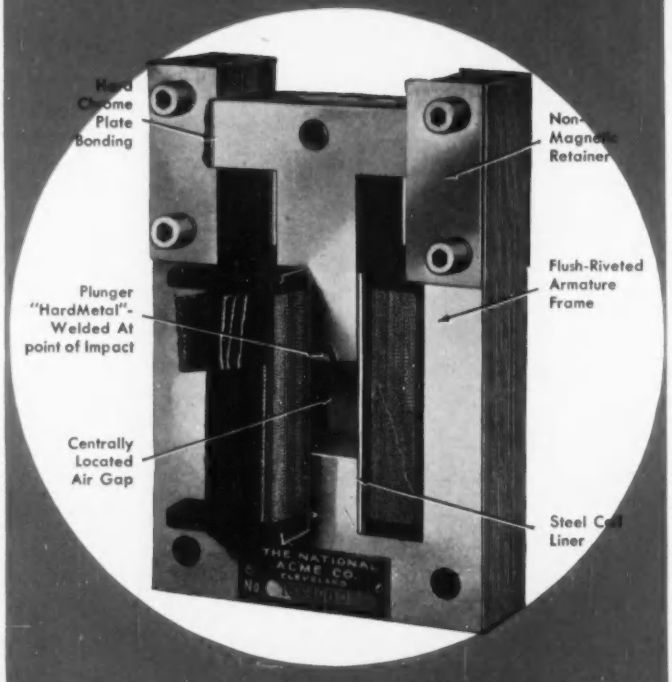
with NAMCO'S exclusive "HARDMETAL"-welded plunger bonding

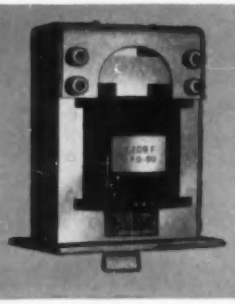
Standard or Custom Models To Fit Your Design

"HardMetal"-welded plunger bonding prevents mushrooming at the vital point of impact—withstands incessant pounding of the plunger on the frame. Long plunger life, and thus long solenoid life, is further insured by hard chrome plating upper guide edges of plunger laminations to reduce friction and wear.

Namco standard solenoids are available in six series of pull and push types; custom-engineered solenoids in every size and type can be made to meet your specifications.

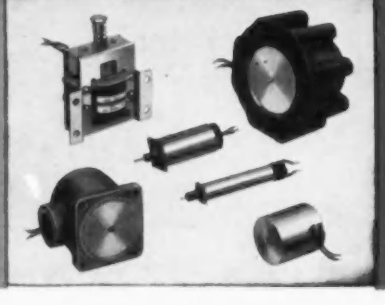
Standard "HardMetal"-Welded Solenoids are furnished push or pull type in sizes with ratings from 2-1/2 to 21 pounds at 1/2" stroke and from 2 to 25 pounds at 1" stroke.





← Saddle stop applied to Series K200 standard Namco push type solenoid.

To meet specific job requirements, solenoids of special shapes and sizes are designed and built through cooperation of our engineers with yours. →



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ELECTRICAL MANUFACTURING DIVISION

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DESIGNING WITH ALUMINUM

This is one of a series of information sheets that discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., Department PD-1, 919 No. Michigan Ave., Chicago 11, Ill.

NO. 26

ADVANTAGES OF ALUMINUM FOIL STRIP FOR ELECTRICAL WINDINGS

Conversions from round copper wire to aluminum interleaved strip windings are bringing improved design, better performance and lower costs to a wide range of mass production applications.

ALUMINUM RIBBON, interleaved with insulation material, has successfully replaced copper in such applications as: transformers for radio and television; motor starters and aircraft accessories; field and rotor windings for motors and generators; coils for solenoids, relays and ignition devices; chokes, filters and a vast range of similar electromechanisms and electronic devices.

Conversion to Foil Strip Offers Design Advantages

Although the design of any electromagnetic unit depends upon its specific application requirements, aluminum ribbon conductor offers several advantages to *all applications* converted from round copper wire:

1. *Reduction in void space often allows equivalent cross-section size.* Whereas round copper wires leave unfilled spaces between strands, the flat aluminum ribbons lie neatly together in a compact mass free of voids. This can often allow equivalent winding cross-section size. Where cooling ducts and layer insulation are used, the aluminum ribbon and interleaving insulation will almost always fit the same winding gap as copper.
2. *Excellent heat dissipation reduces operating temperature.* Aluminum conducts heat better than any insulation or impregnating material. A ribbon-wound coil has substantially the same temperature throughout a layer of conductor because each layer is a solid conductor and dissipates heat to the outside. Absence of voids eliminates formation of local "hot spots"—has reduced temperature as much as 100°F. This control of temperature normally allows a reduced aluminum cross-section for equal current carrying capacity.
3. *Lower area factor helps reduce cost and weight.* Because ribbon wound coils generally operate at temperatures 20 or more degrees (F.) lower than wire wound coils, it is possible to reduce the 1.64:1 aluminum-to-copper area ratio that is theoretically necessary. In actual use, area factors are about 1.5 and occasionally have been as low as 1.25, making possible weight reductions of over 50% ... with cost savings of 30 to 40% for copper wire conversions in sizes #24 or larger.
4. *Manufacturing method reduces problem of conductor tensile strength.* Because wire-drawing tensions are absent in manufacturing the slit aluminum ribbons, and because aluminum's better heat dissipation lowers coil temperatures, comparative conductor strength has little significance. Aluminum ribbon conductor is readily available and readily adaptable to high production techniques.
5. *Effective joining methods available at low cost.* A wide variety of joining techniques and equipment—all proved in thousands of high-production electrical devices—offer economy equal or better than copper for both initial cost and maintenance.

Two Design Approaches Meet Conversion Problem

The fundamental design problem in converting from copper to aluminum conductor is, of course, to provide for and accommodate the additional coil cross-section needed for equal conductivity, and at the same time provide equal dissipation of heat. Two basic approaches may be taken to this problem.

First, the conductor cross-section may simply be increased by the appropriate factor (1.5) to give the same ampere turns and resistance; or second, the wiring area may be changed to allow a better ratio of conductor to insulation where space is critical or the coil may be split and connected in series to further help this conductor to insulation ratio.

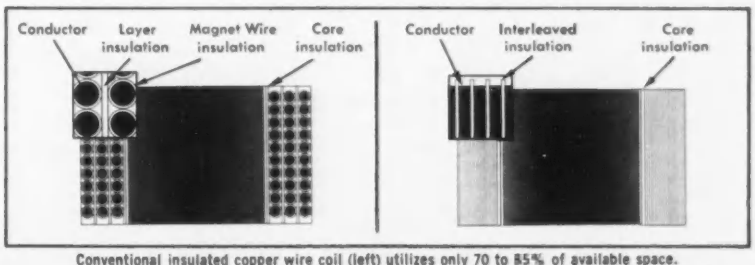
Designing for a compromise between these two approaches is favored by the physical shape of aluminum strip conductor, and allows the designer to make use of the advantages of both approaches. The aluminum ribbons are produced by slitting from foil, which may be mill-rolled to any requested thickness, and thus are available in any desired combination of gauge and width, unrestricted to standard gauge sizes. And—to the designer's advantage—the aluminum conductor proportions may be exactly determined *by the rectangular geometry* of the wiring cross-section.

Elimination of the voids between circular conductor sections together with the better dissipation of heat due to this design results in working temperatures normally about 20°F. cooler than in round wire. Some ribbon wound coils have reduced "hot spot" temperatures by as much as 100°F., and have accepted without damage excess loadings that have destroyed electromagnetically-equivalent copper wire wound coils.

When aluminum ribbon conductor is substituted for copper wire to give equal current carrying capacity and equivalent resistance, the aluminum conductor assembly is little or no larger and *sometimes smaller*—than its copper prototype.

Insulation Need Not Have High Dielectric Strength

Because the potential between successive wraps is usually low, the insulation materials between layers normally does not require high dielectric



Conventional insulated copper wire coil (left) utilizes only 70 to 85% of available space. Aluminum interleaved strip conductor coil (right) utilizes up to 97% of overall space.

strength. Condenser paper 0.00025" in thickness may be used in many applications where space is highly critical.

"Mylar"* and "Teflon"* plastics have excellent dielectric, tensile and scuffing strength. They are available in gauges down to 0.00025" and accept, without aging, higher temperatures than paper. The higher cost of "Mylar" for Class B insulation, and the still higher cost of "Teflon" for Class H insulation are justified for conversion of high operating temperature coils.

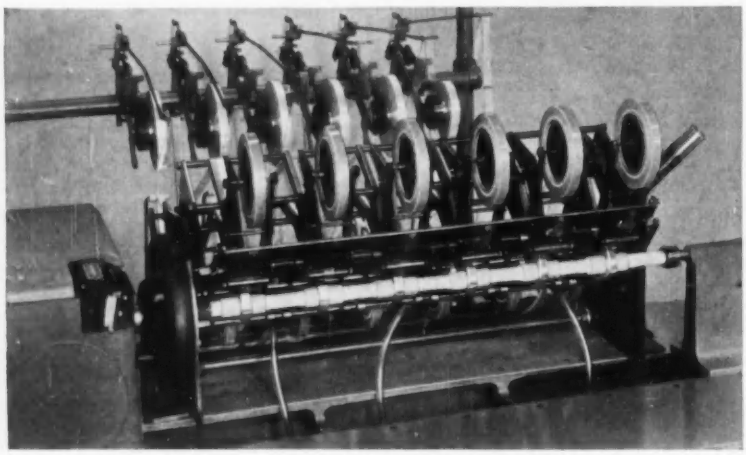
Fixed coatings such as resins and enamels are efficient and eliminate separate interleaving. Although they are not commercially available at this time, should they become more readily available in the future, this factor would further reduce material cost.

Anodized conductor similarly needs no separate insulation, resists temperatures up to 750°F., and eliminates the need for separate interleaving materials. Extreme care is necessary to prevent edge crazing of the anodic coating during the winding operations. The anodic coating is inherently porous and requires sealers against moisture. Such sealers are presently limited to a maximum temperature of about 400°F.

The strip insulation lowest in weight and cost is condenser tissue of suitable gauge. The paper is limited by a tendency to become brittle after lengthy exposure to temperatures above 250°F., but otherwise is an excellent general purpose insulator. Because of its natural porosity, it may be readily impregnated with resin sealers for protection against moisture, or with sealer-adhesive materials to bind the interleaved coil into an integral unit.

Most of the existing machinery for handling single-wound, heavier size conductors can be adapted readily to the use of aluminum ribbon by adding little more than an unwinding reel, a suitable tension device and guides for the insulation and aluminum strip.

Equipment for multiple winding of smaller coils often is too specialized for easy adaptation, but usually may be converted by more detailed alterations. In present practice, both conductor ribbons and insulation strips are wound from reels of pre-slit material.



Modern foil coil machine designed specifically for aluminum ribbon coil windings. (Universal Winding Company, Providence, R. I.)

Above: Tinned copper wire pressure welded to aluminum foil. **Below:** Koldweld tools made by Utica Drop Forge and Tool Division of Kelsey-Hayes Company.

*Dupont trade names.

Tested Joining Methods Offer Economy, Versatility

The joining of round, flat, and stranded leads of aluminum or copper to ribbon conductors of aluminum has been accomplished in a variety of ways. Soldering or brazing of leads and terminals may be accomplished by use of suitable aluminum fluxes and solders, by ultrasonic soldering techniques, or by the use of fiber-glass brushing in conjunction with recommended aluminum solders on the heavier gauge materials.

Cold or hot pressure-welding is an extremely economical method by which the metals are pressed into plastic-flow merging of surfaces to give a true weld. Fusion welding by torch flame or electric arc may also be used for the heavier gauge materials. Standard crimping procedures have been used effectively although the ribbon conductor shape also permits punching to receive wide flange connecting parts without need for crimping.

Where dissimilar metal joints are used and are susceptible to high humidity conditions, suitable resin sealers may be applied at the joint to minimize the possibility of galvanic corrosion.

The operating and cost efficiencies of aluminum strip conductor are most marked when replacing copper wire of #24 AWG or larger, but savings have been realized by conversions through #30 gauge. Economies in conductor cost, including insulation, have been recorded from 30 to 40%.

Kaiser Aluminum does not manufacture electromagnetic coils or insulation materials, but has wide availabilities of aluminum ribbon conductor and a special technical staff to assist coil manufacturers and users in all details relating to the use of its conductor materials in their products. Inquiries for such assistance are welcomed and sample coils can be fabricated to customer specifications for their evaluation in possible conversions.

For immediate attention to your request for this technical service or samples, or for more detailed information, contact the Kaiser Aluminum sales office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 22, Calif.

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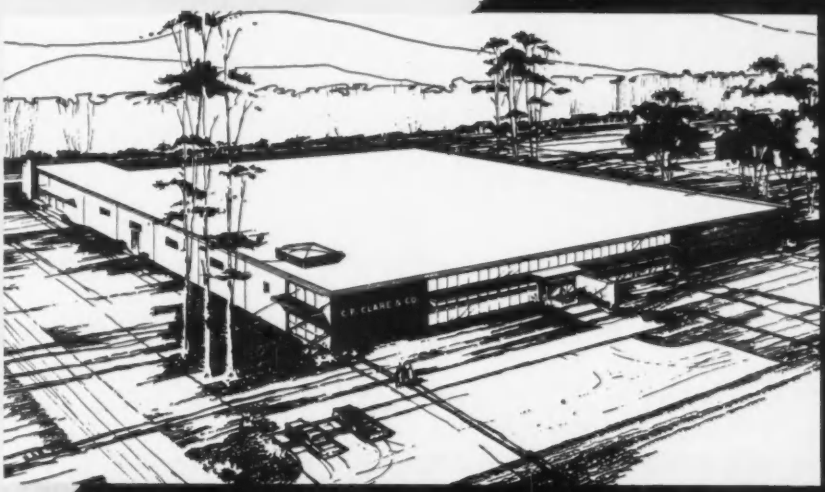


New C. P. Clare & Co. plant at Fairview, N. C. will expand manufacturing facilities which have been under way in Fairview for two years.

Before midyear 1958 CLARE will be serving customers from a new factory at Fairview, N. C.—a facility that will match the manufacturing advantages of our Chicago plant, itself only five years old.

This CLARE expansion is made necessary by the tremendous growth of the electronics industry and the increasing demand for precise components, including relays whose life can be measured in billions of operations.

Facilities of virtually clinical cleanliness are required for this kind of precision. That's why CLARE plants in both Chicago and Fairview maintain complete control of the temperature, humidity and cleanliness of the air . . . immaculate walls and floors . . . powerful, shadowless lights, for assembly of small parts.

If yours is a product whose long life, reliable performance and freedom from maintenance depends on relays, it will pay you to know ALL about CLARE relays. C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15, Ontario. Cable Address: CLARELAY

CLARE RELAYS

FIRST in the industrial field

PROBLEM:

How to get extra wear resistance high core strength and good toughness in impact mechanism of new power hammer

SOLUTION: Nickel alloy steel—Carburize!

The parts shown in section above are the heart of the impact mechanism of Ingersoll-Rand's new lightweight electric power hammer.

They're made of 8640, a nickel alloy steel. By carburizing the parts, I-R gets a surface with extra wear resistance while retaining the very high strength of the fully hardened core to take the impact and stress of 2300 blows a minute.

Piston, crosshead and both outer and inner spring seats are made this way. They can withstand terrific, continuous pounding and shock load *with a minimum of wear . . . without deforming or cracking.*

Your requirements may be altogether different from Ingersoll-Rand's. But when you need a metal with the "extra" properties there's a grade of nickel alloy steel to cover practically every fabricating or service demand.

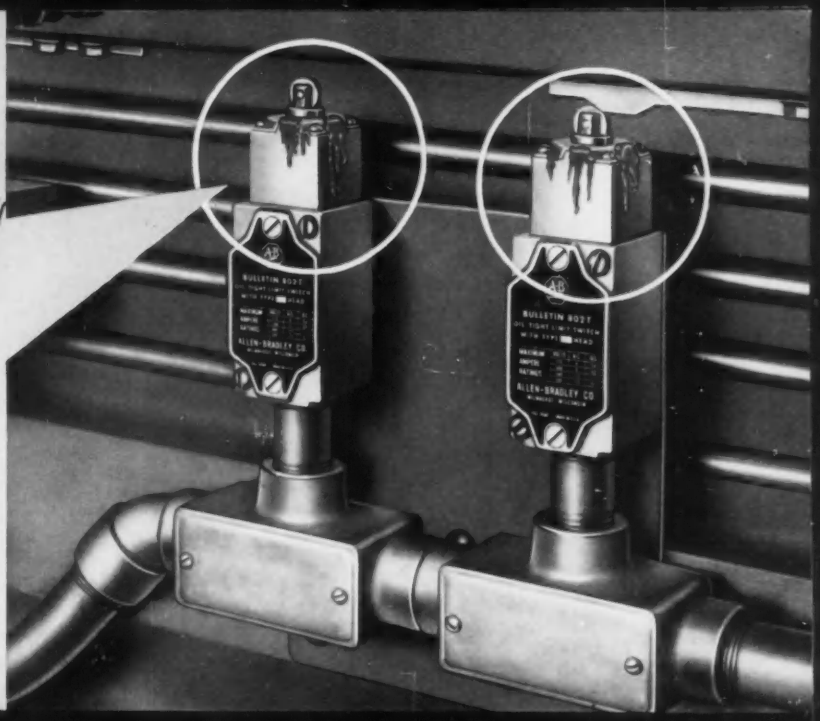
Send us details of your application and we'll be happy to help you.

New electric power hammer by Ingersoll-Rand, New York, N. Y., can be used for breaking concrete (above), stone, macadam . . . for drilling, roughing, cleaning, caulking, scaling, chipping, seaming and dozens of other jobs. Unit weighs only 12 lbs. and features an exclusive "spring floating" piston.

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

Completely Oil-Sealed!



A-B QUALITY

802TC Side Push Rod Type

802TF Rod Type

802TA Roller Lever Type

802TB Top Push Rod Type with Plastic Window

802TAO Roller Lever Type for Cavity Mounting

802TG Adjustable Roller Lever Type

SEALED HEAD KEEPS OUT OIL, COOLANT, METAL CHIPS ...your guarantee of reliable limit switch operation!

With *completely sealed* operating heads, as well as sealed switch bodies, Allen-Bradley Bulletin 802T oiltight limit switches provide maximum reliability in limit switch operation for your modern, high speed production machines. The sealed head excludes oil, dirt, and metal chips from the operating mechanism ... the spring return, momentary contact operators cannot become sluggish and stick.

The maintenance free, double break, silver alloy contacts are sealed in the oiltight body. Interchangeable operating heads are available with various push rods and levers which can be mounted in any one of four positions. Oiltight transparent plastic covers, for inspecting wiring without removing the cover, are available for most units.

Here's a line of *quality* limit switches in which each type will provide millions of trouble free operations. Have your A-B control engineer acquaint you with this latest development—another advance in limit switch design.

ALLEN-BRADLEY
MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

11-57-MR

NOW... ALLEN-BRADLEY PRECISION-TYPE LIMIT SWITCHES ARE ALSO OILTIGHT!

OILTIGHT HEAD — Newly designed head on push type seals out oil. Roller lever types have sealed operating shafts.

OILTIGHT BODY — Synthetic rubber gasket between housing and plate excludes oil and coolant from operating mechanism.

Allen-Bradley precision-type limit switches combine very close operating tolerances with such a sturdy construction that they can be used for any industrial application. Now this line of limit switches has been further improved by making them completely oiltight.

Especially designed for use where the motion to operate the limit switch is measured in thousandths of an inch, these Allen-Bradley limit switches can henceforth be employed in applications where oils, coolants, and dust are present.

Allen-Bradley Bulletin 802 oiltight precision limit switches have a positive snap action mechanism which prevents any possibility of a "dead center" . . . no matter how slowly the actuating force is applied. They are available in both the spring return and maintained contact construction. And all have maintenance free, silver alloy contacts.

Specify these Allen-Bradley oiltight limit switches where "precision" operation is required and where dirt and oil could cause trouble.

Push rod type. Plastic cover, for inspection without removing cover, made for most units.

Roller lever type limit switch with lever on right side. Also available with lever on left side.

Roller lever precision-type limit switch with roller lever in front of the switch body.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.
In Canada—
Allen-Bradley Canada Ltd., Galt, Ont.

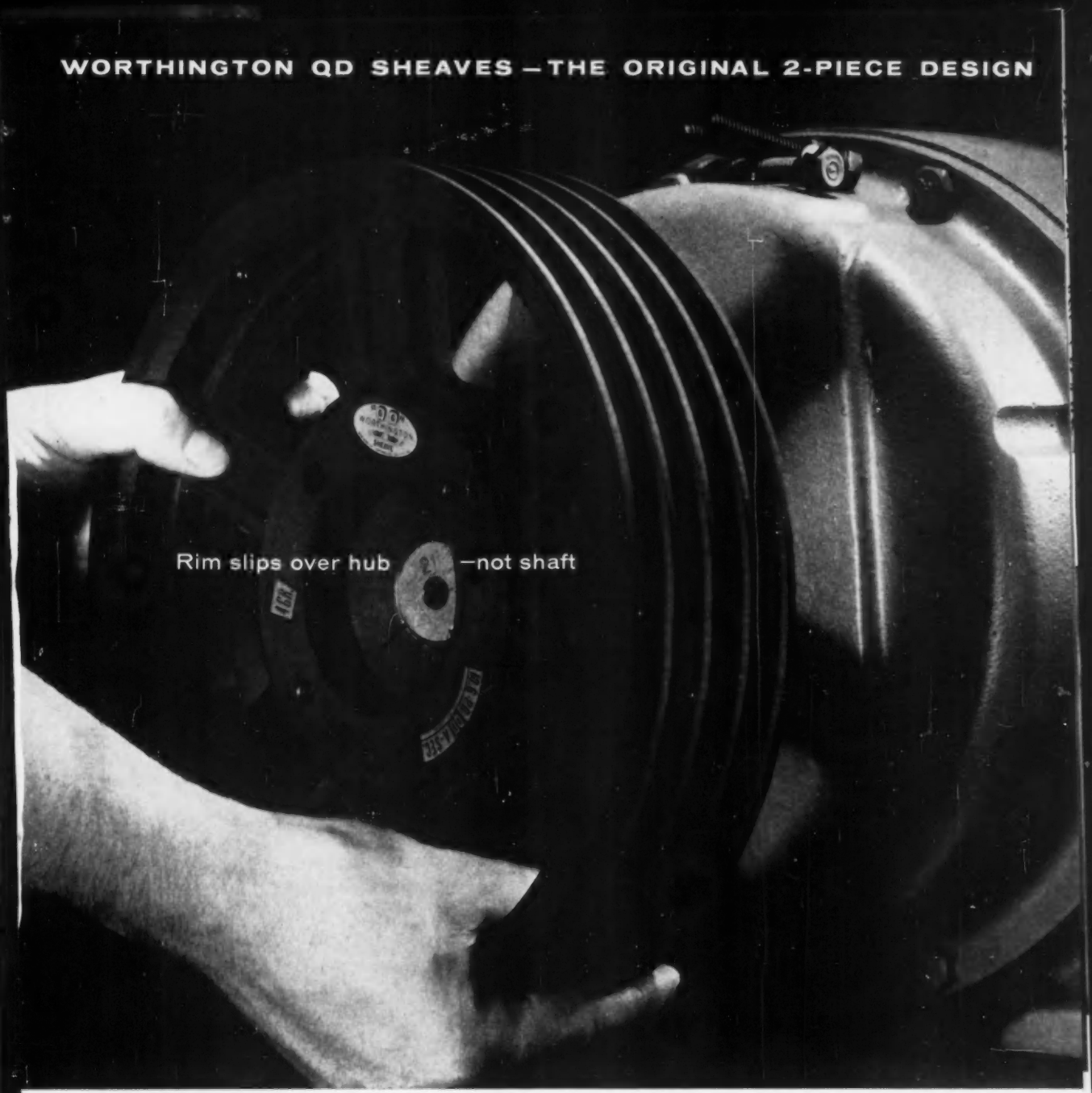
ALSO—GENERAL PURPOSE LIMIT SWITCHES

Bulletin 801 general purpose limit switches in standard or heavy duty ratings. Maintained or momentary contacts with slow or snap action. Silver alloy contacts used throughout this line.

A-B QUALITY

11-57-MR

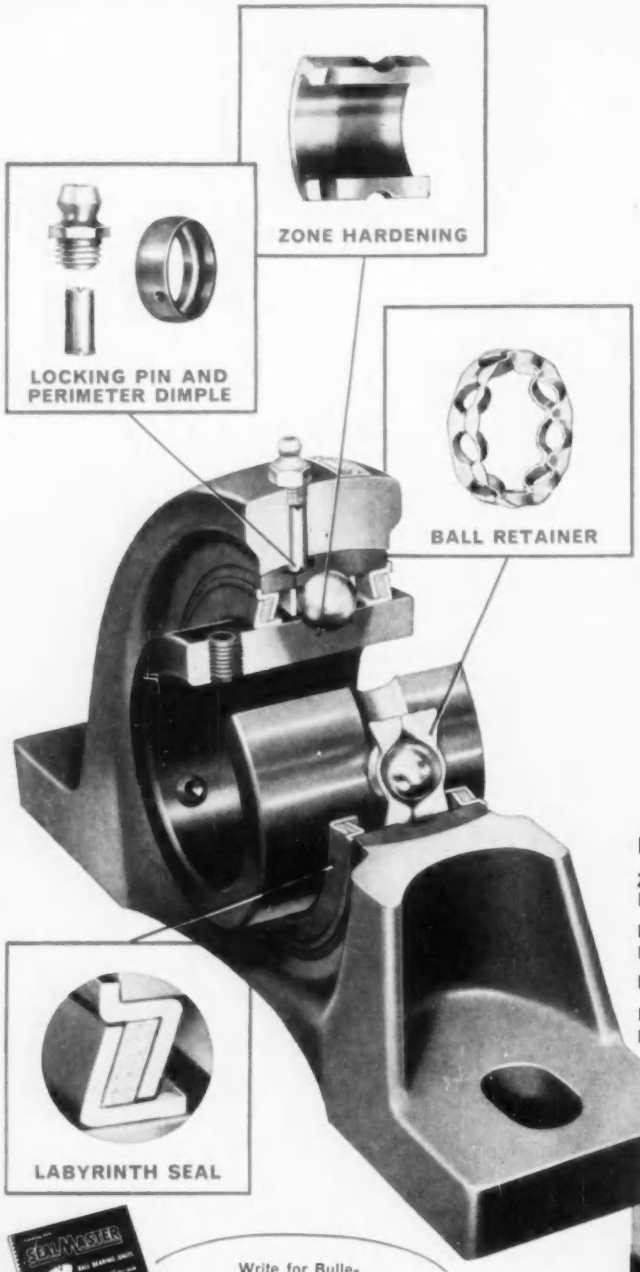
WORTHINGTON QD SHEAVES—THE ORIGINAL 2-PIECE DESIGN



EASY ON!

Only Worthington QD sheaves have the exclusive two-piece design that lets you install the sheave *one part at a time*. No heavy rim and hub combination to delicately inch into place. The QD's tapered hub slides easily on the shaft, locks with a cap screw for permanent alignment. A set screw locks the key in place. Sheave pulls up tight with heat treated bolts.

WORTHINGTON



THIS EXCLUSIVE COMBINATION OF FEATURES IS YOURS WITH SEALMASTER BALL BEARING UNITS ... PLUS QUICK, EASY MOUNTING!

Slip a SEALMASTER Ball Bearing Unit into place on the shaft—tighten two set screws and you have the answer to ease of mounting in a bearing unit. SEALMASTER'S exclusive combination of features take over from there, providing smooth, trouble-free performance and long bearing life.

FEATURES:

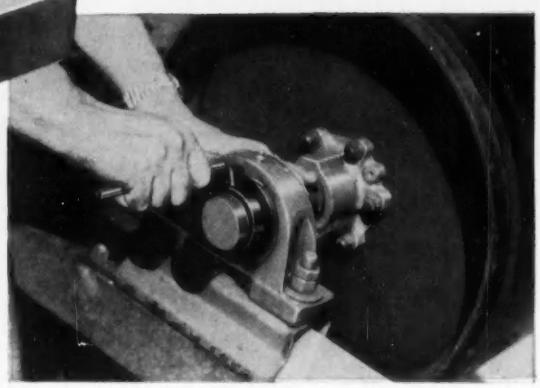
ZONE HARDENING . . . assures positive race-to-shaft holding power.

LAND RIDDEN BALL RETAINER . . . traps grease and prevents "churning."

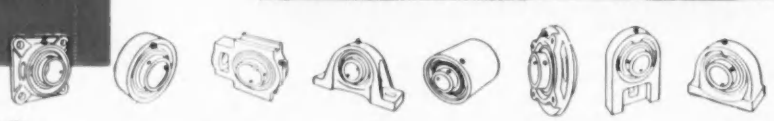
LABYRINTH SEAL . . . keeps dust and dirt out, lubricant in.

LOCKING PIN & PERIMETER DIMPLE . . . assures positive lubrication.

Write for Bulletin 454 for full information.

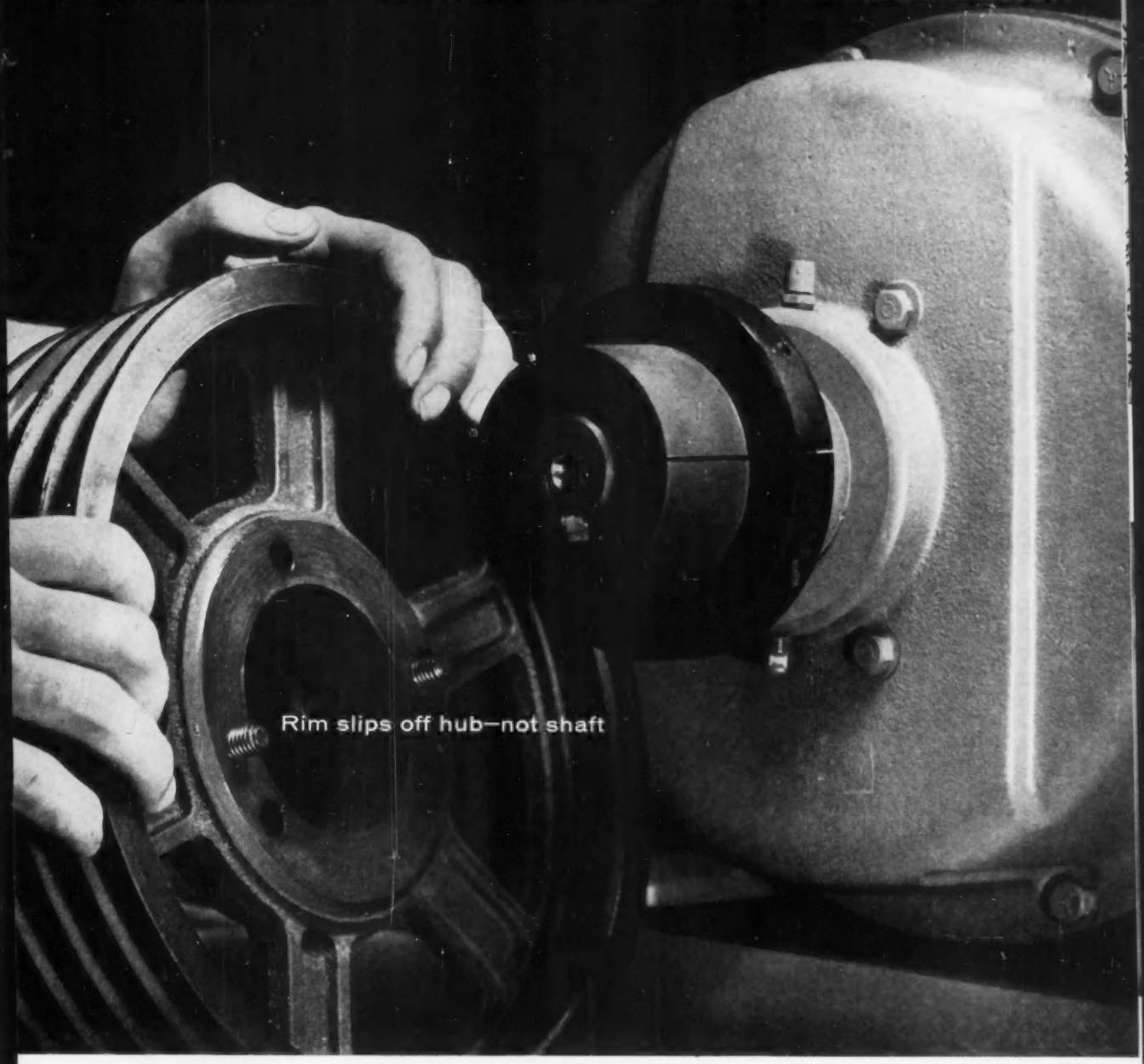


SEALMASTER® BALL BEARING UNITS



SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO. 9 RIDGEWAY AVENUE, AURORA, ILL.

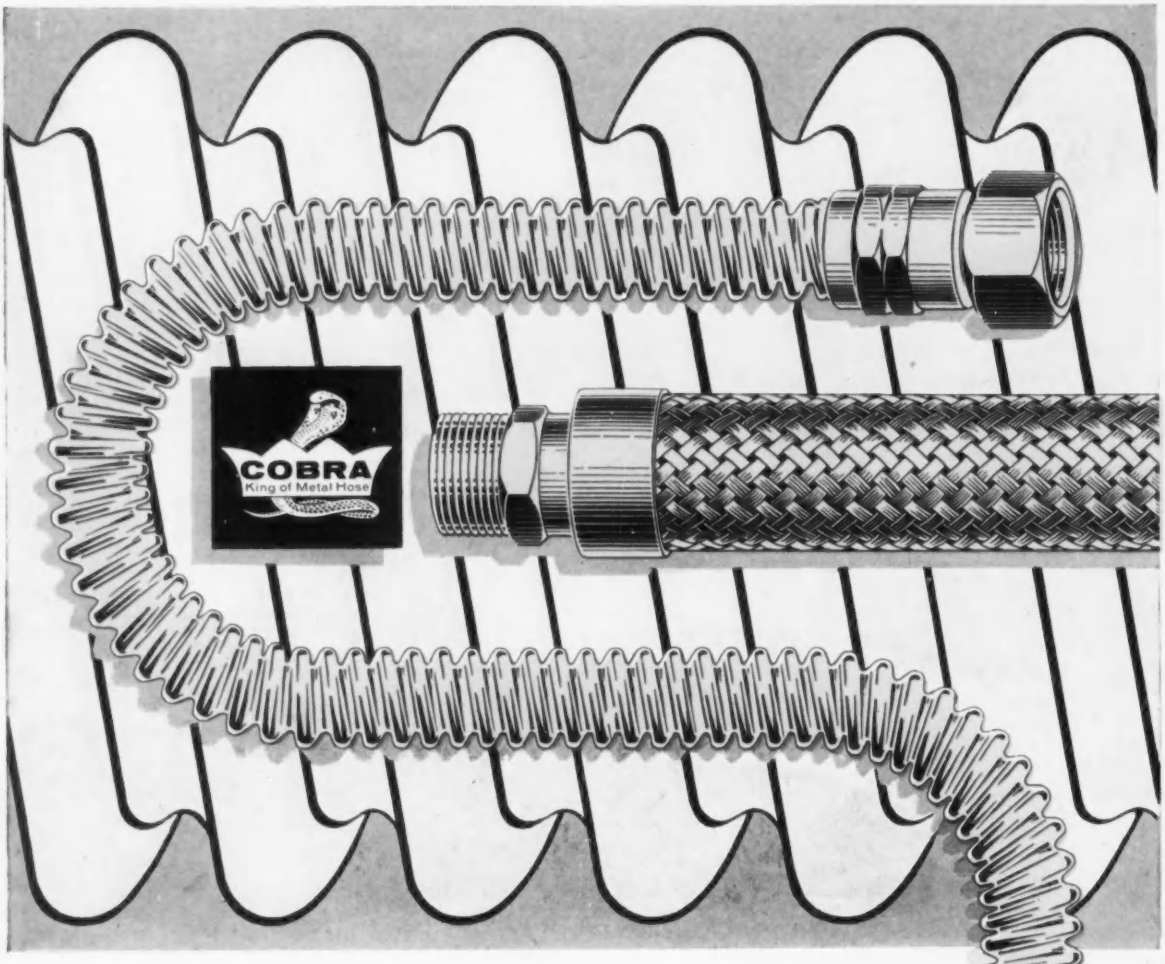
WORTHINGTON QD SHEAVES—THE ORIGINAL 2-PIECE DESIGN



EASY OFF!

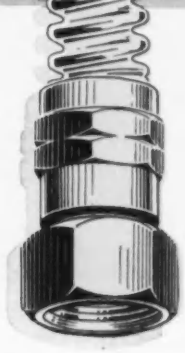
Loosen the big bolts, use two for jack screws and the sheave practically comes off by itself! To change speed it's a simple matter to mount a larger or smaller sheave on the hub which remains aligned on the shaft. This easy on, easy off feature is the big advantage of Worthington QD sheaves—the only design that lets you install or remove one part at a time.

WORTHINGTON



Stoppers for vibration and noise start with **CHASE® BRASS TUBE**

In making their wide variety of metal hoses and flexible connectors, Cobra Metal Hose uses red brass tube made by Chase, "folds" it in their own special "Rafold" process, then treats and bright-dips the finished product. They report Chase tube assures vital elasticity and ease of working, consistently good grain structure, highly accurate temper and wall thickness—doesn't crack or separate in processing. Cobra reports an extra **"PLUS"** from Chase, too—technical help with production and metallurgical problems. This same help is ready to serve you—along with Chase alloys that are *right* to meet your specific needs. See Chase today, locally or at Waterbury 20, Connecticut.



Gas range connector, flexible nipple and vibration absorber made by Cobra Metal Hose of Chase red brass tube, using their special "Rafold" process and final bright-dipping.

Chase®

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT
SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass, Copper and Stainless Steel

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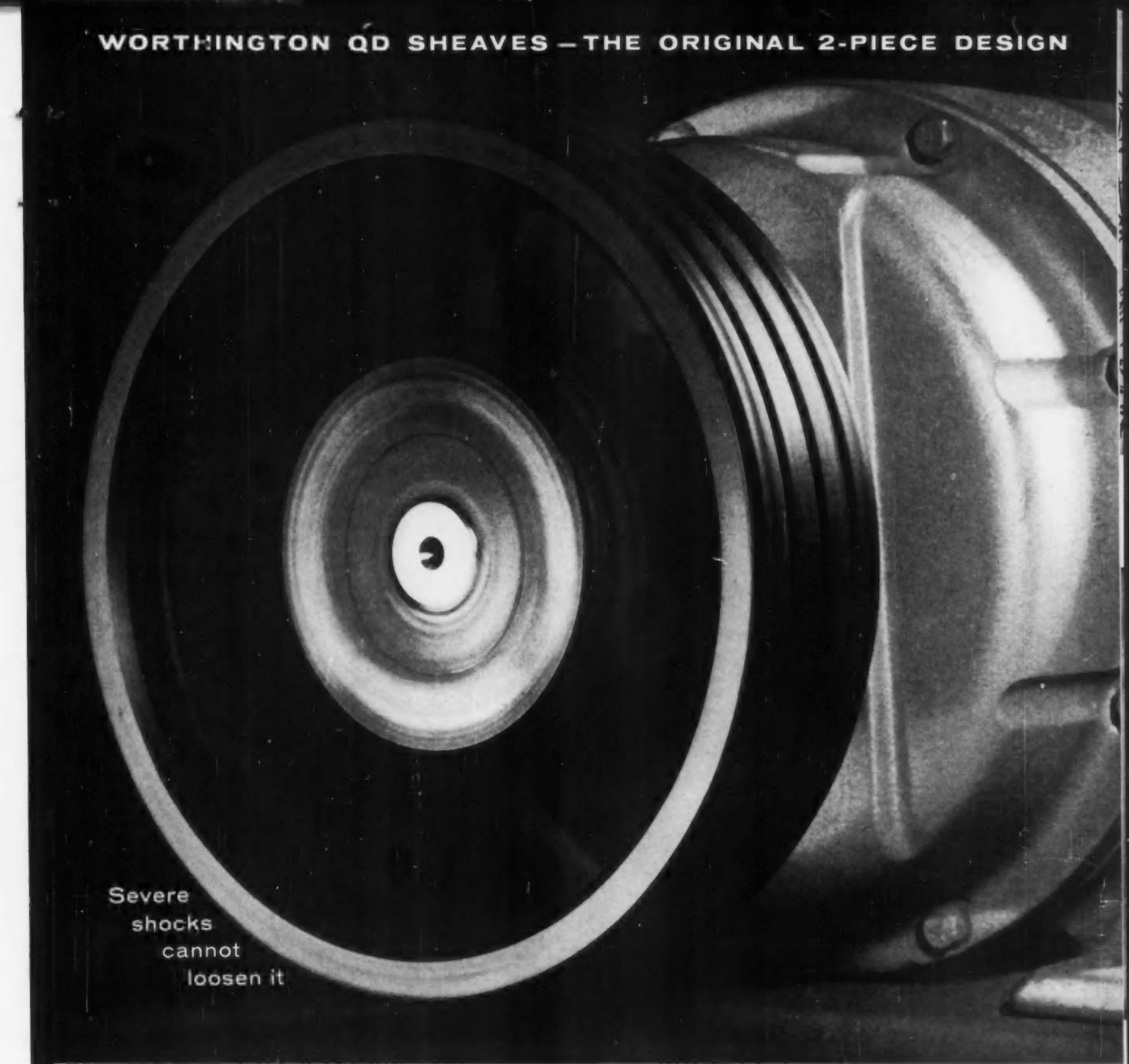
WORTHINGTON QD SHEAVES—THE ORIGINAL 2-PIECE DESIGN

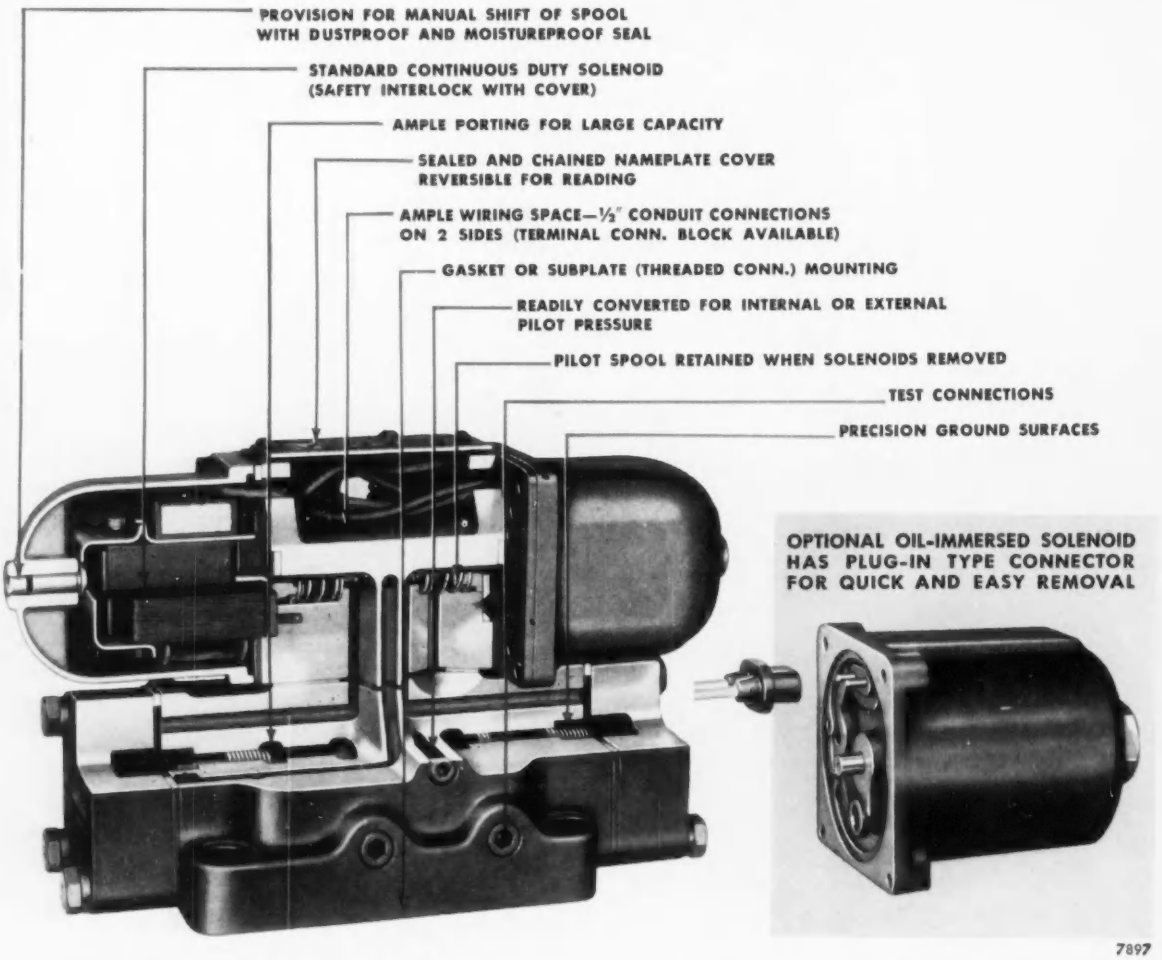


ALWAYS TIGHT!

Severe shock overloads or reversing applications cannot loosen a Worthington QD sheave. The secret is the two-piece construction with the vice-like grip. Tightening the pull-up bolts forces the tapered hub to securely lock the shaft as tight as if the sheaves were integrally cast with the shaft (comparable to a press fit.) To keep the key from drifting, the set screw—another Worthington exclusive—anchors it in position.

WORTHINGTON

Only VICKERS® DIRECTIONAL VALVES Have *all* These Features


PROVISION FOR MANUAL SHIFT OF SPOOL WITH DUSTPROOF AND MOISTUREPROOF SEAL
STANDARD CONTINUOUS DUTY SOLENOID (SAFETY INTERLOCK WITH COVER)
AMPLE PORTING FOR LARGE CAPACITY
SEALED AND CHAINED NAMEPLATE COVER REVERSIBLE FOR READING
AMPLE WIRING SPACE—½" CONDUIT CONNECTIONS ON 2 SIDES (TERMINAL CONN. BLOCK AVAILABLE)
GASKET OR SUBPLATE (THREADED CONN.) MOUNTING
READILY CONVERTED FOR INTERNAL OR EXTERNAL PILOT PRESSURE
PILOT SPOOL RETAINED WHEN SOLENOIDS REMOVED
TEST CONNECTIONS
PRECISION GROUND SURFACES
OPTIONAL OIL-IMMERSED SOLENOID HAS PLUG-IN TYPE CONNECTOR FOR QUICK AND EASY REMOVAL
7897

REDUCED DOWN-TIME
LONGER SOLENOID LIFE
LESS MAINTENANCE
EASIER INSTALLATION

Vickers hydraulic 2- and 4-way valves provide the optimum in directional control. They are compact, versatile, and are designed for heavy duty, continuous and rapid cycling operation on all types of industrial machinery. More than a decade of application experience and years of research and development back all the valves' features.

Seven spool types satisfy a wide variety of circuit needs and operate at pressures to 3000 psi. Optional oil-immersed solenoids operate cooler, increasing service life 20 to 30 times.

Installation is simplified with ease of wiring and a minimum of piping. The valves are available for gasket or sub-plate mounting. Mounting position is unrestricted except in "no-spring" models. The optional oil-immersed solenoid has a plug-in type connector and is available in all standard voltages. Field modification of existing units can be made to incorporate heavy-duty, oil-immersed solenoids.

The valves conform to JIC Standards and are available in ⅛" and ¼" direct solenoid operated models . . . ¾", 1¼", 2", and 3" solenoid controlled pilot operated models. These valves cover the flow range from 1.25 gpm to 320 gpm.

For further information, write for Installation Drawing I-182412.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
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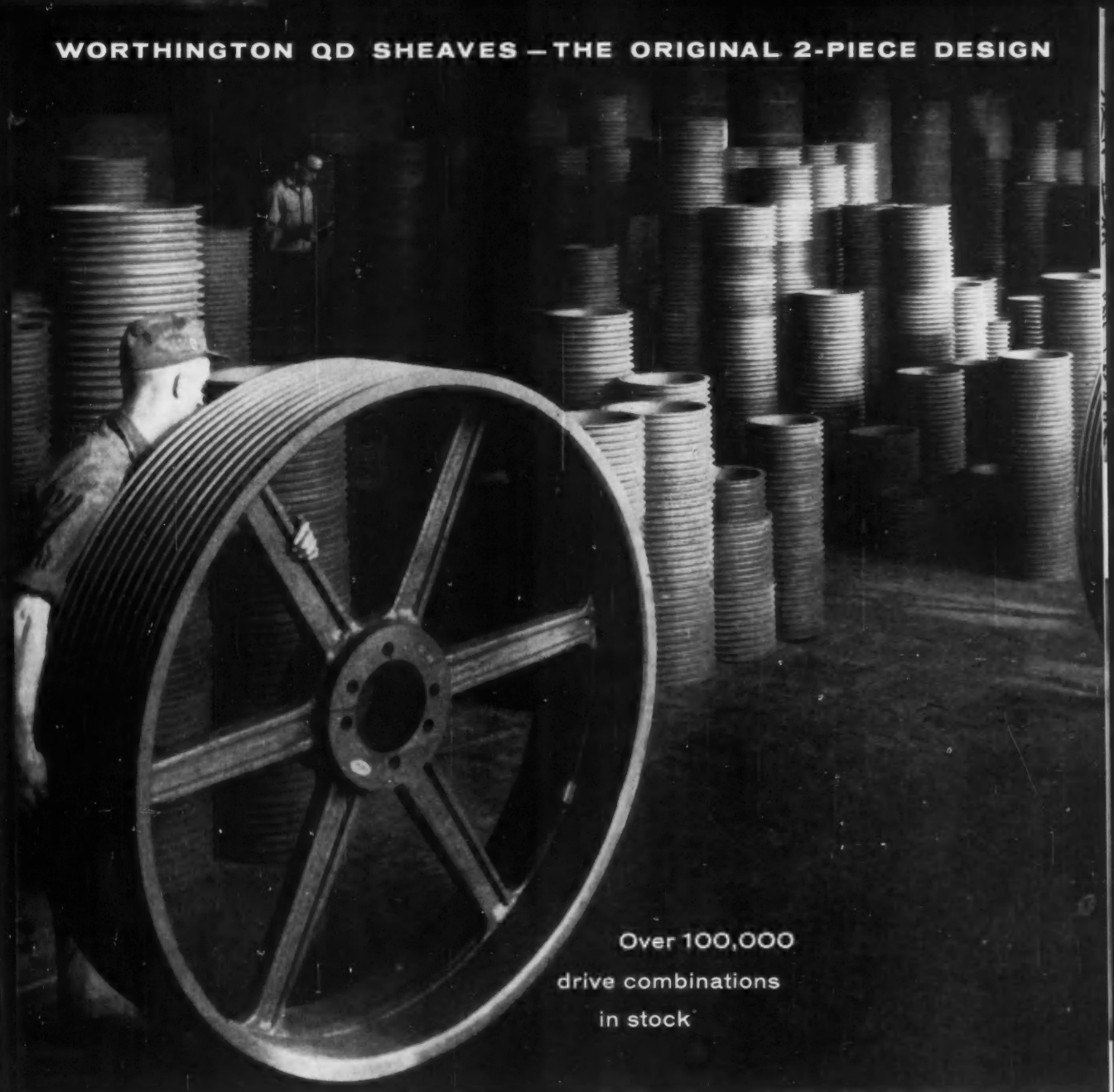
FACTORIES ALSO IN AUSTRALIA, ENGLAND AND GERMANY
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto and Montreal

WORTHINGTON QD SHEAVES — THE ORIGINAL 2-PIECE DESIGN



COMPLETE STOCK!

You can get Worthington QD sheave stock service anywhere in the U. S. A. More than 350 distributors stock Worthington sheaves and Worthington-Goodyear V-belts. In 13 giant factory warehouses alone there are over 250,000 units in stock from fractional hp sheaves to 1,000 hp giants. For your free copy of a 100-page Multi-V-Drive Manual that enables you to select the right sheave and V-belt in 3 minutes flat write to Section MV-74, Worthington Corp., Harrison, N. J.

WORTHINGTON

Always, at SKF, you will receive unbiased advice

because

– All four basic types of anti-friction bearings are available from **SKF**.

because

– They offer an extraordinarily wide range of sizes and combinations to meet virtually any requirement.

because

– Their long experience in the widest variety of bearing applications is your assurance of receiving sound recommendations.

because

– Thousands of manufacturers have been using the **SKF** Bearing Advisory Service for many years – always with good results. This dependable service is available to you, too. 7754

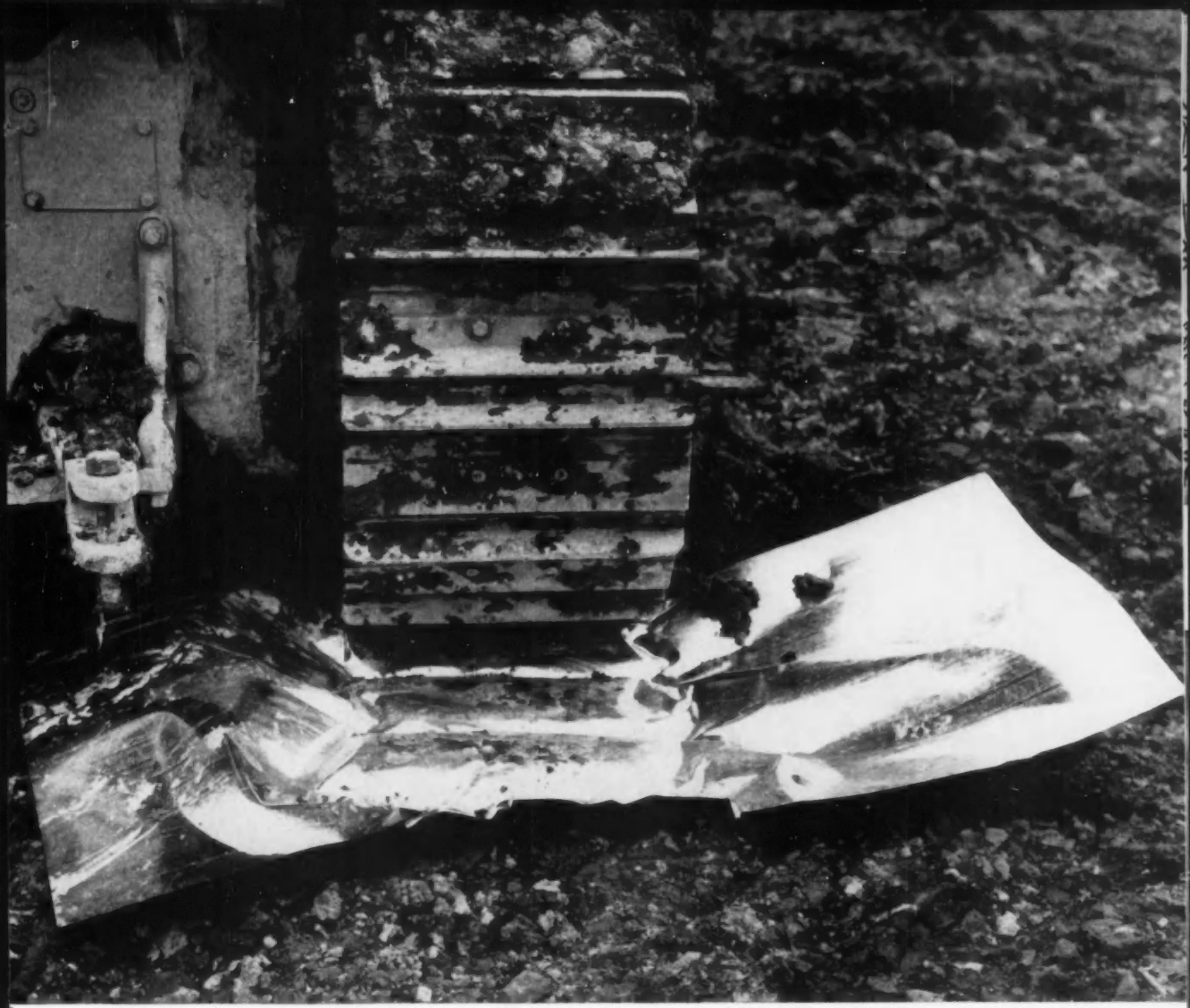
SKF®

EVERY TYPE–EVERY USE

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings (Tyson®)*

® Reg. U.S. Pat. Off.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.



WE TORTURED THAT WEIRKOTE® TILL IT HURT US TO LOOK!

The heavy tractor's treads crunched into the Weirkote steel, rocked back and forth, gave Weirkote's tight zinc coating a wicked test.

It passed perfectly.

Weirkote shrugs off punishment like that—or far worse—in everyday production. Its continuous-process zinc coating goes through all the severe fabrication steps flawlessly. Spin it, deep-draw it, crimp it, roll-form or extrude it. There's no flaking or peeling when Weirkote's on the job.

And look at this for savings! Because Weirkote's zinc coating stays put, you can eliminate the cost of plating, painting or redipping after fabrication. In many jobs, the lubricating property of the zinc coating will prolong die life, too.

Free Weirkote Booklet!

Send for all the facts on Weirkote. Write Weirton Steel Company, Dept. D-5, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

Variety—you can choose from a wide range of finishes for magnesium

Smart, modern furniture is just one example of how finishes for magnesium are widening design horizons. Whether for appearance, protection, or a combination of both, the right finish is available. Magnesium can be painted, chemically treated, electroplated, and coated with plastic or rubber.

To meet the rigorous standards set by the aircraft industry, there are air dried and baked paint finishes with excellent adhesion, maximum imperviousness and good wear resistance. Various types of chemical pickling provide the right paint base. Anodizing provides exceptional corrosion, heat and abrasion resistance. In addition, any metal which can be applied by electroplating may be deposited on magnesium.

What about your products? If you're not making use of magnesium lightness, strength and durability—and the variety of finishes for magnesium—there's no better time to start than right now. Contact your nearest Dow sales office or write to us for more information. THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1405H.

YOU CAN DEPEND ON DOW

Problem: To produce a rugged, dependable motor case for Sunbeam Mixmasters—in sufficient quantity to meet customer's need. Production cost must be low, to keep price competitive.

Solution: Working closely with Sunbeam, Stewart Die Casting engineers developed an intricate two-cavity die, consisting of slide, cores, and one loose piece—all held to extremely close tolerances. The result was a precision casting that can be produced economically with a minimum of rejects . . . a motor case that gives dependable, long-lasting service under all conditions.

Stewart found the solution and made delivery on time!

This is just one of many complicated die castings that Stewart has developed promptly . . . and has produced in quantity *at low cost.*

Nearly half a century of experience, plus unexcelled production facilities, enables Stewart to bring you fast, practical solutions to any die casting problem.

Whatever type of die casting you need—large or small, simple or intricate—you can count on Stewart for a quality job . . . completed and delivered on schedule.

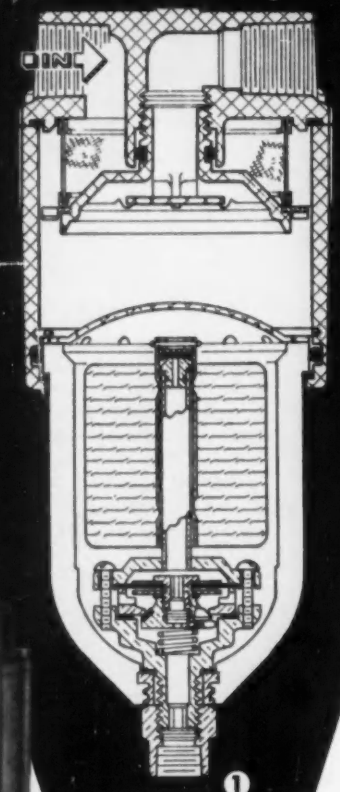
Stewart **DIE CASTING**

Division of STEWART-WARNER CORPORATION

Chicago, Illinois: 4535 Fullerton Avenue • Bridgeport, Connecticut: 275 Warren Street

46 YEARS OF SERVICE TO INDUSTRY

NEW Advanced design Norgren AUTOMATIC-DRAIN AIR LINE FILTERS



NOW—24 Models to choose from

- Transparent Bowls—¼", ⅜", ½", ¾", 1"
- Metal Bowls—¼", ⅜", ½"

❶ MORE EFFICIENT WATER REMOVAL

❷ WIDER OPERATING RANGE 5 psi to 250 psi, up to 200° F.

BETTER... MORE EFFICIENT FILTRATION OF COMPRESSED AIR

You Get These Important Advantages:

- **More Efficient Water Removal**
  Greatly increased water removal efficiency—even at air flows 143% higher than ever before.
- **Operates Over Wider Pressure Range**
  Top efficiency at as low as 5 psi for all models and as high as 250 psi for metal bowl type.
- **Operates Over Wider Temperature Range**
  New metal bowl models in ¼", ⅜" and ½" sizes extend temperature range to 200° F.
- **Withstand Rougher Usage**
  Metal bowl models are ideal for applications likely to get rough usage.
- **Simplified Drain Mechanism**
  More efficient operation. Fewer parts.
- **Eliminates Manual Draining**
  Collected liquid is drained automatically—cannot return to air line. Drain operates as long as pressure is on the system.
- **Choice of Three Filter Elements**
  74, 64 or 25 micron elements—interchangeable.

Wherever Air is Used in Industry

C. A. NORGREN CO.

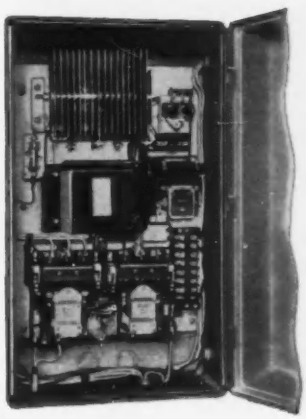
3428 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

For complete information, call your nearby Norgren representative listed in your telephone directory—

OR WRITE FACTORY FOR NEW NO. 800 CATALOG

IMPROVE MACHINE TOOL PERFORMANCE

—with Westinghouse components ...ready today



Stamping press performance improved at this plant when they used Westinghouse DYNAC braking control to reduce stopping time 95 percent.

MP-3057-I

YOU CAN BE SURE...IF IT'S Westinghouse

Westinghouse Cypak static control reduces maintenance costs in form-grinding automotive transmission parts.

THESE COMPONENTS OFFER IMMEDIATE ANSWERS

...for more dependable operation
...for quicker stopping...for faster duty cycles

You don't have to wait for electrical answers in making machine tool improvements or modifications. Outstanding design and improvement in Westinghouse control components, systems and drives help designers and their customers to act now.

For example, *Westinghouse DYNAC® braking control*, cover photo, reduces press stopping time 95 percent. The eight minutes it previously took to stop the heavy flywheel on this press have been cut to just 24 seconds with DYNAC. This operation is now getting the fastest, smoothest stops possible to increase production.

Cypak static control*, above, has already outlasted conventional relays previously used on form grinders at a large automobile manufacturer's plant. No down time for control maintenance has been necessary on this highly repetitive operation in over 17 months.

*Trade-Mark

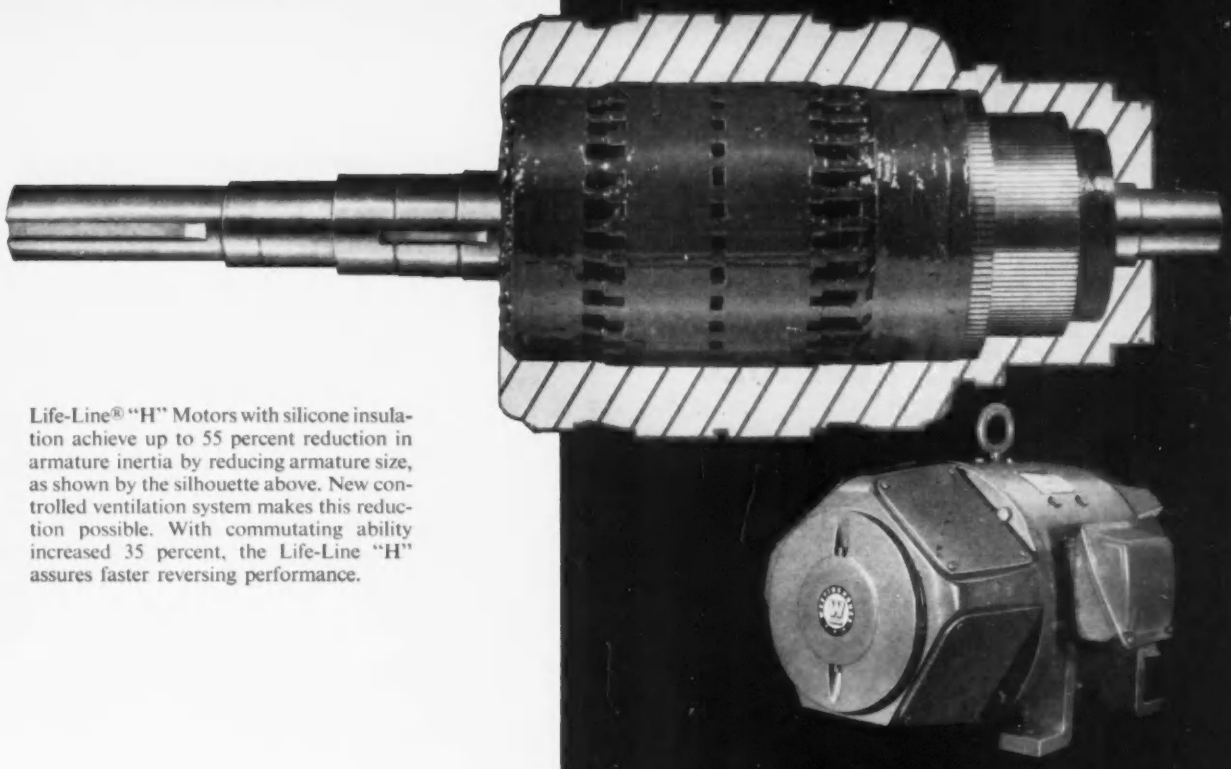
Westinghouse Life-Line® "H" Motors, right, make possible faster, smoother reversing cycles to save production time. Westinghouse reduced armature inertia up to 55 percent and increased commutating ability 35 percent to provide in the Life-Line "H" Motor the fastest d-c motor response available to improve machine tool performance.

Westinghouse right-angle gearmotor, right, delivers up to 195 percent more torque capacity than conventional single-reduction worm gearmotors between 9:1 and 60:1 speed reduction ratios. It's the result of more efficient, double-reduction gear train. You'll find Westinghouse packaged motor-reducer drives offer rugged dependability, too, for improved machine performance.

Developments like these help you design and build machine tools that answer your customers' needs for increased productivity at lower cost. Whatever the function you want performed . . . sensing, transmitting, recording, computing, control or driving . . . think of Westinghouse components first!

MP-3057-2

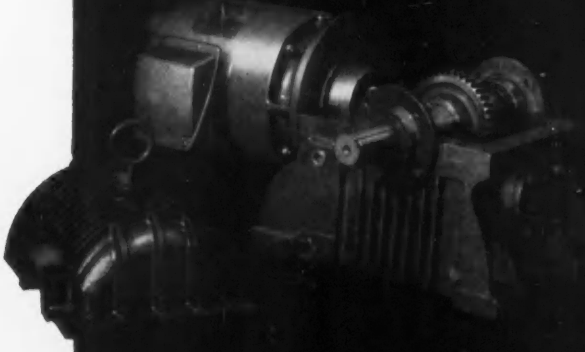
YOU CAN BE SURE...IF IT'S Westinghouse



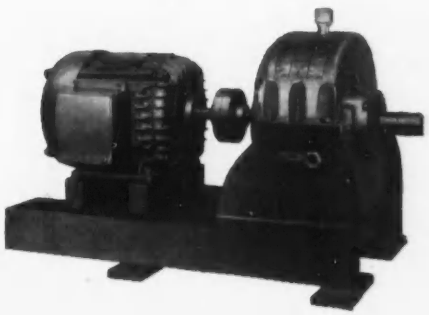
Life-Line® "H" Motors with silicone insulation achieve up to 55 percent reduction in armature inertia by reducing armature size, as shown by the silhouette above. New controlled ventilation system makes this reduction possible. With commutating ability increased 35 percent, the Life-Line "H" assures faster reversing performance.

Push-lite pushbuttons combine the functions of both a pushbutton and indication light in one unit. One push transmits the signal and energizes the indicating light. Push-lites are oiltight — part of the complete Oil-Tite* line of 1,500,000 pushbutton control arrangements available from stock.

*Trade-Mark



Either Westinghouse gearmotors or packaged motor-reducer drives save design time with a wide selection in horsepower, speed ratios, direction of power take-off, mounting and coupling methods. MP-3057-3



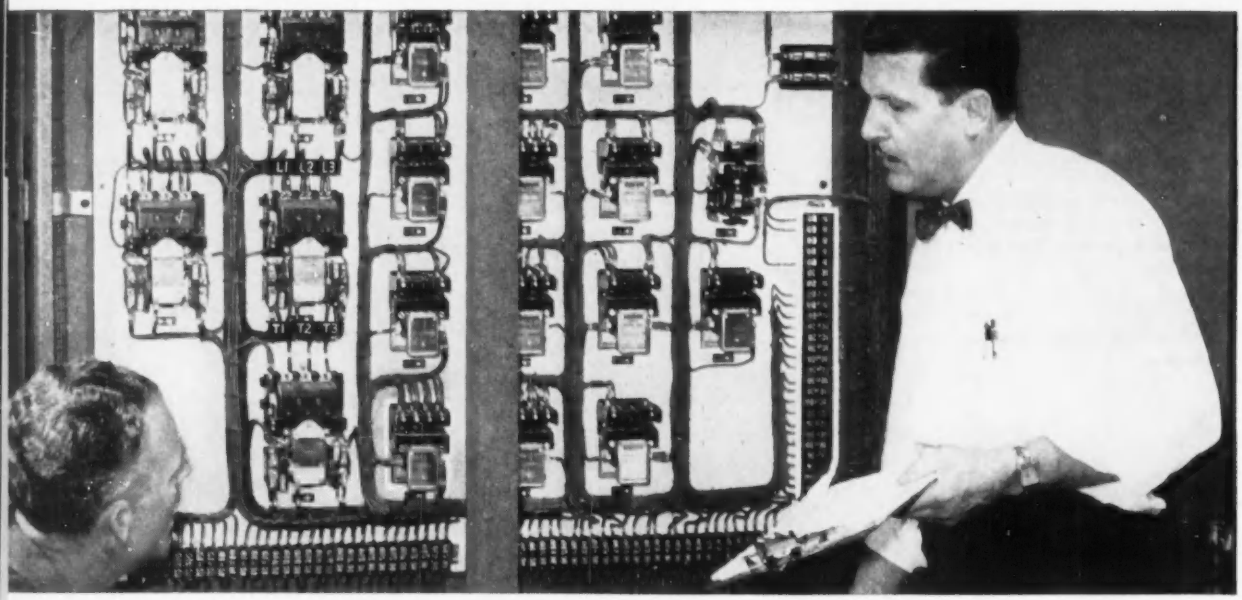
WESTINGHOUSE SERVICES AND FACILITIES ARE FLEXIBLE

HELP YOU FROM DESIGN BOARD TO TEST FLOOR

Add experienced manpower to your machine tool projects by simply calling your local Westinghouse representative. Whether you have a problem in drive system design, in component development or in manufacture and assembly, Westinghouse facilities provide economical ways to get the answer on schedule.

Westinghouse research . . . field engineering service . . . local manufacturing and repair plants . . . renewal parts stocks . . . are all ready to extend you service in any situation.

And when you select Westinghouse components, your customers will recognize electrical leadership. You'll benefit from one-supplier responsibility for products of outstanding quality, backed by more than 70 years of electrical experience. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. MP-3057-4



YOU CAN BE SURE... IF IT'S Westinghouse

Westinghouse serves these O. E. M. industries

- Air conditioning
- Appliance
- Communications—electronic
- Electric apparatus
- Fan and blower
- Machine tool
- Materials handling
- Panelboard and switchboard
- Prime mover equipment
- Pump and compressor
- Miscellaneous machinery

. . . with these components

- Motors—gearmotors
- Adjustable-speed drives
- Gearing
- Controls—relays—circuit breakers
- Semiconductors
- Cypak*
- Magamp* magnetic amplifiers
- Rectifiers
- Heating elements—thermostats
- Transformers
- Instruments
- DYNAC® magnetic braking

*Trade-Mark

ALL MACHINED TO EXACT CUSTOMER SPECIFICATIONS FROM Spaulding PRODUCTS

Spaulding Products are adaptable to intricate machining operations. They are readily sheared, sawed, turned, punched, drilled, threaded, swaged and formed.

Spaulding's fabricating departments are especially equipped and staffed to perform these operations on these materials. Even the most difficult shapes are turned out quickly, accurately and economically.

When you need a material with the unique electrical, chemical and physical properties combined in the numerous types and grades of Spaulding materials, you can specify Spaulding with assurance that the parts delivered to you will be fabricated to your precise specifications.

THE PROPERTIES OF SPAULDING MATERIALS INCLUDE

Great mechanical strength, extremely light weight, durability, chemical inertness, excellent machinery qualities, arc resistance, deionizing ability and low loss electrical insulation.

WE MAKE AND FABRICATE

VULCANIZED FIBRE: In sheets, rods, tubes and fabricated parts.
ARMITE: Thin Insulation (Fish Paper) in sheets, rolls, coils and fabricated parts.
SPAULDITE: (Laminated Thermosetting Plastic) in sheets, rods, tubes and fabricated parts.
SPAULDO: Motor Insulation in sheets, rolls, coils, slot cells and other fabricated parts.
SPAULDING FIBRE BOARD: In sheets and fabricated parts.
SPAULDING T BOARD: A superior Transformer Board in sheets and fabricated parts.
MATERIALS HANDLING PRODUCTS: Factory Trucks, Boxes, Barrels, Trays, etc.
SPAULDING FABRICATING FACILITIES: Spaulding's fabricating facilities for these products are unsurpassed the world over. You can save time and money by letting us do your fabrication. We'll be glad to quote on specific jobs without obligation.

SPAULDING FIBRE COMPANY, INC. 310 WHEELER ST., TONAWANDA, N. Y.

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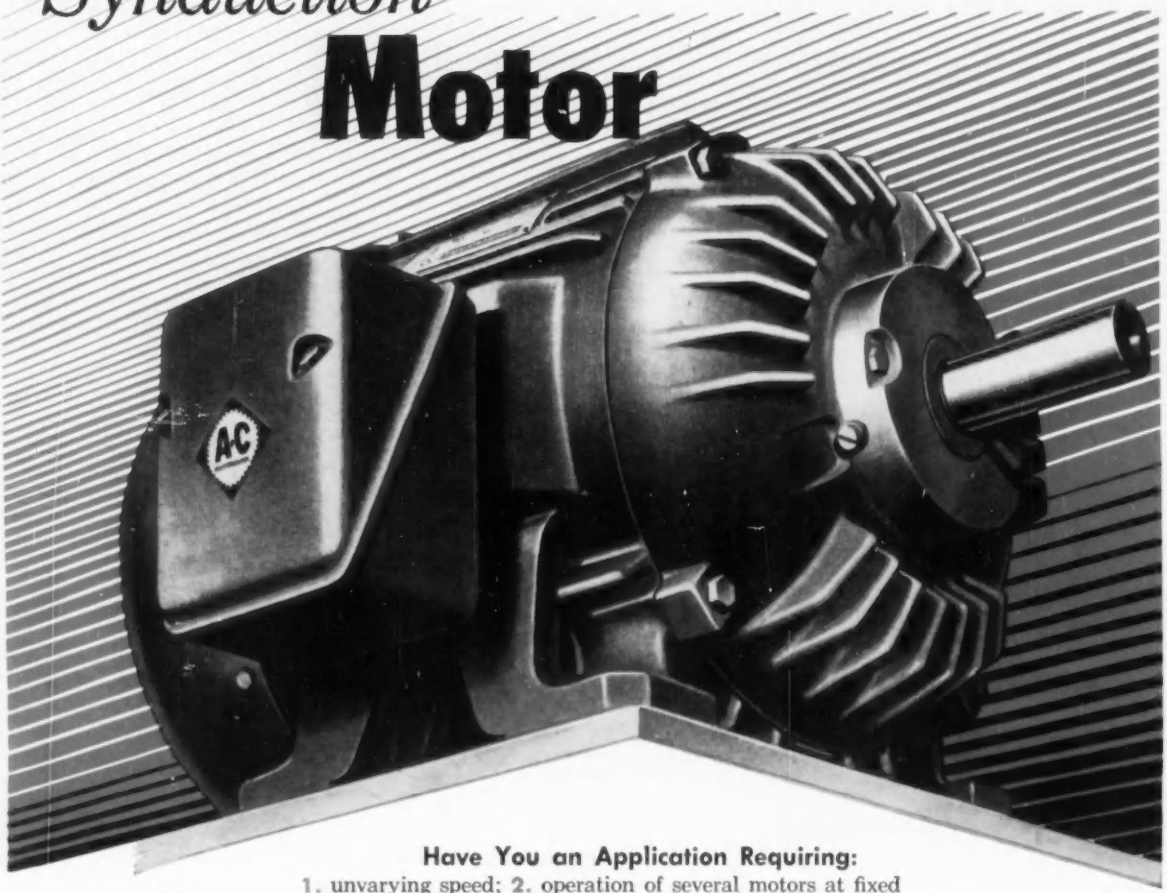
NOW dependable constant speed at less cost

Here's a motor with all the constant speed benefits of synchronous design at initial low cost — with the dependability of an induction motor. It's the NEW *SYNDUCTION* motor, built specially for applications from ¼ to 40 hp.

DEPENDABLE — Now constant speed, regardless of load or voltage changes, is sure . . . depends only on frequency. *Synduction* motor's simple die-cast rotor has no brushes, collector rings, nor insulated rotor windings.

LOW COST—Simple across-the-line control is all that's needed. Further, design permits use of frames smaller than usual reluctance-type motors. Purchase price is well below that of ordinary reluctance-type motors.

New *Synduction* Motor



Have You an Application Requiring:

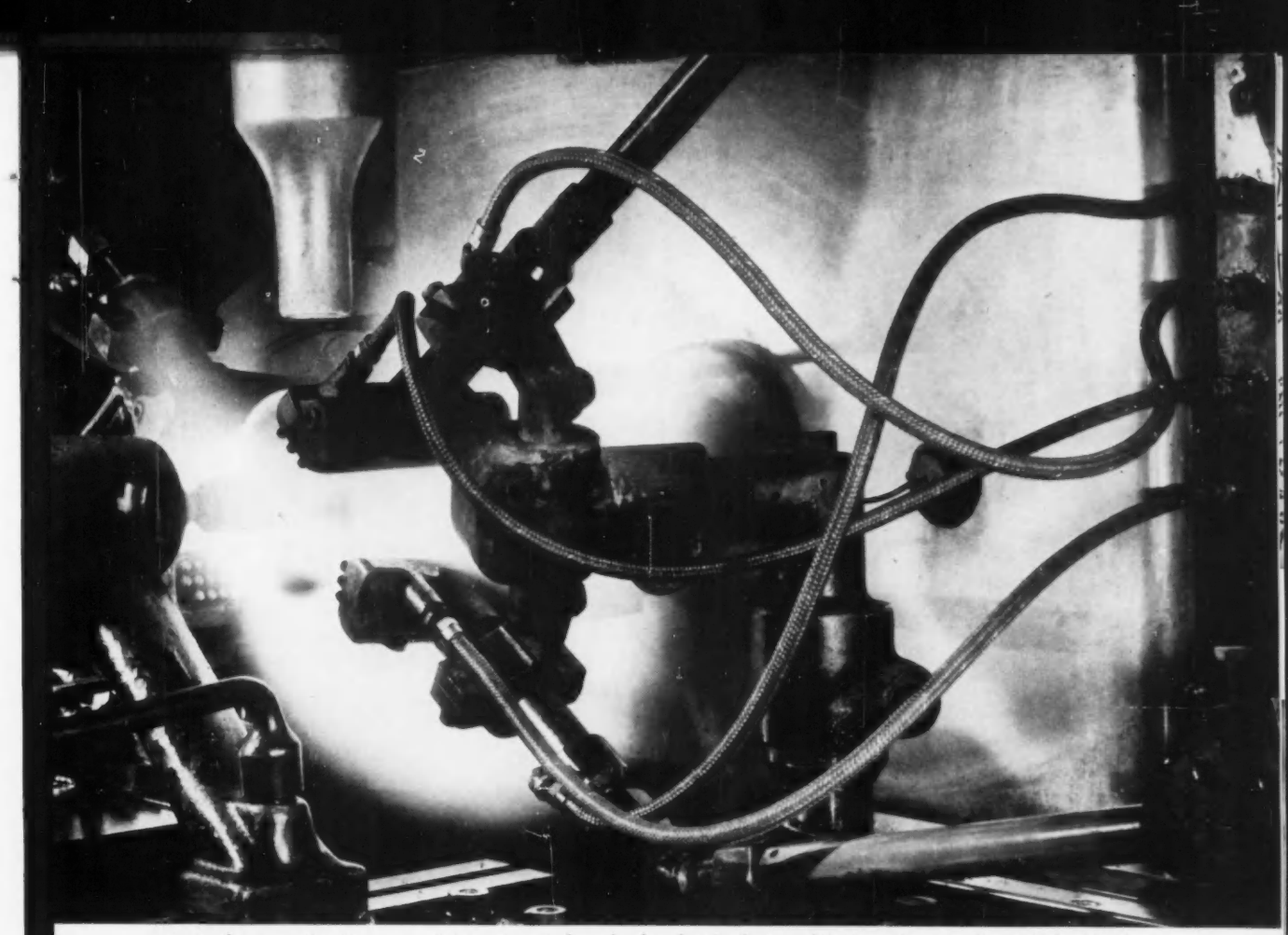
1. unvarying speed; 2. operation of several motors at fixed speed ratios; 3. adjustable speed with minimum variation at any speed setting? If so, Allis-Chalmers invites your inquiry. Contact your nearby A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin, for Bulletin 51B8440.

Synduction is an Allis-Chalmers trademark.

A-C ALLIS-CHALMERS

A-5113

ALLIS-CHALMERS



A gear for a new Hoe Newspaper Printing Press is flame-hardened at the factory of R. Hoe & Co., Inc., Bronx, N. Y. 1" I.D. seamless bronze American Flexible Metal Hose on the flame hardening machine, shown here, conveys acetylene gas.

Design Problem:

Leakproof gas lines that must flex
. . . withstand heat from outside
. . . corrosive attack from within

Answer:

American Metal Hose

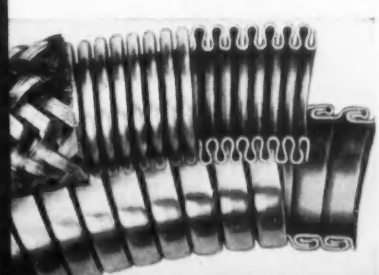
This machine hardens, brazes, and heat processes metal products and parts. The flame heads are adjustable; so the hoses conveying the fuel gas must be flexible. And they must be tough! Corrosive gas attacks them from the inside. High heat is a constant enemy on the outside. Yet they must be leakproof. For safety's sake, they must not fail.

The engineers found the right answer: American Flexible Metal Hose. It delivers more service hours per dollar!

Available in wide range of diameters in bronze, brass, aluminum, steel, monel, stainless steel and other metals—American Flexible Metal Hose is being used by countless manufacturers to convey almost every conceivable gas and liquid . . . to absorb vibration . . . absorb expansion and contraction in lines due to temperature changes . . . facilitate installation, especially in cramped spaces . . . to solve the problem of misalignment.

American furnishes flexible metal and Teflon connectors to your specifications . . . ready for immediate installation. Consult your nearby American Metal Hose representative for engineering help when planning your next job. Just released! New 64-page catalog chock-full of useful information on flexible metal hose and tubing. Write for your free copy: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn.

57176



BASIC TYPES

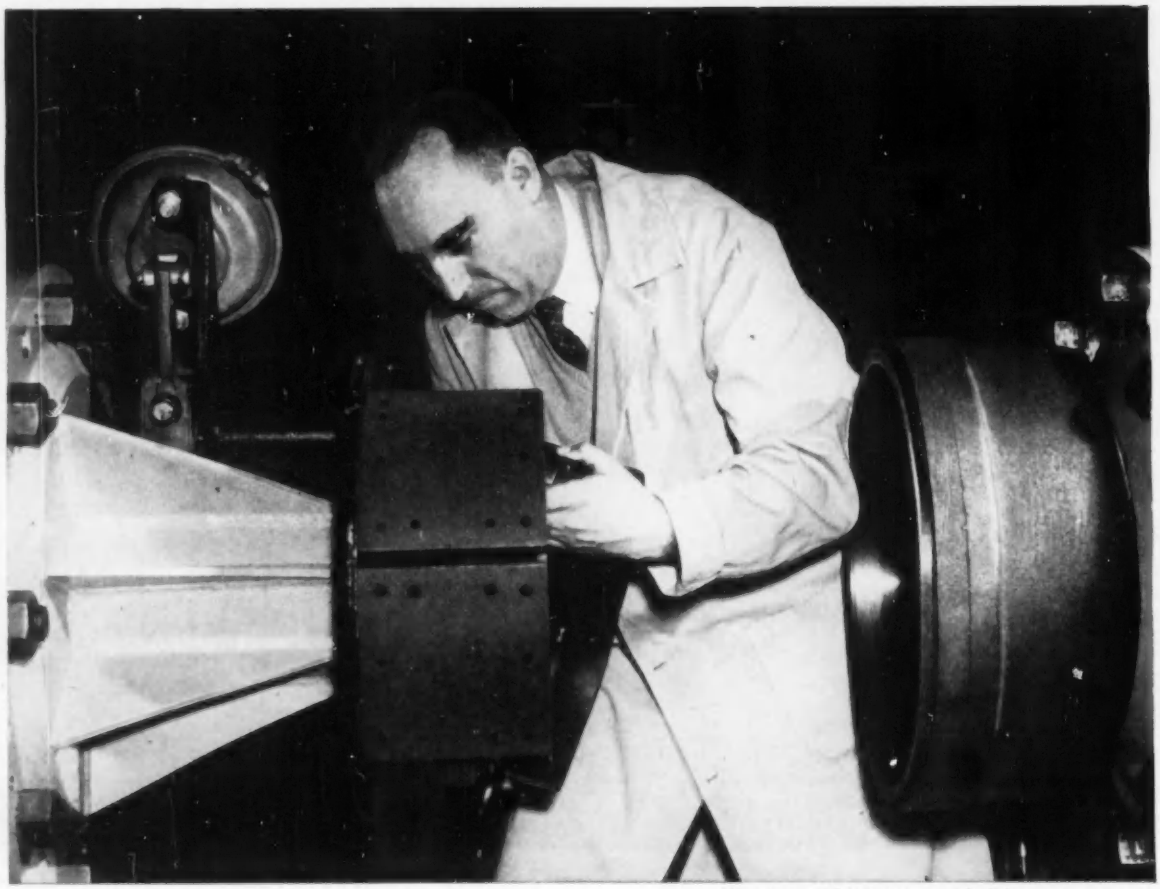
Seamless corrugated and Strip-wound. Both types available in a wide range of sizes and styles in any workable metal. Furnished with or without end fittings attached.

WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL HOSE AND TUBING

AN **ANACONDA**® PRODUCT



Experimental block being readied for torture test on Johns-Manville's Inertia Dynamometer—the world's largest unit designed for friction material testing.

Man in charge of putting more mileage into J-M Brake Blocks

Creating new and better brake blocks is a never-ending responsibility of J-M engineers. Working with the very latest in scientific development equipment, these men are blazing new trails in improved friction material performance.

Over the years, Johns-Manville has offered a wide choice of thoroughly proved, high-quality, high-performance brake linings, brake blocks and clutch facings. This superiority stems from engineering and production techniques that assure uniformly highest quality. These techniques also provide volume production, rapid delivery and lowest unit cost.

Chances are a J-M material incorporating all the properties you need for your friction applications is already available. If not, let us help you find the solution. The Johns-Manville engineering staff, a superbly equipped development laboratory, and skill gained through 99 years of manufacturing experience, are at your service.

Your Johns-Manville Representative will gladly tell you more about this service, or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JOHNS MANVILLE JM PRODUCTS

Johns-Manville

Molded and Woven Brake Linings

Molded and Woven Clutch Facings

Molded Brake Blocks

Molded Segments for Automatic Transmissions

Woven Transmission Band Linings

FILE UP TO 3,000 DRAWINGS IN A 25" x 25" WALL SPACE

WITH *Pack* **INTER LOCK** *Files*

CONVAIR, in San Diego, saved 20% on space when they installed Inter-Lock files.

• Add individual file tubes horizontally or vertically as needed
• Cone-shaped opening for fingertip removal of drawings
• Individual indexing on file door
• Arrange in any size or shape stack to fit available space
• File single rolled drawing, or 3 or 4 individually rolled drawings, or group-roll up to 30 per tube

SAVE SPACE

Inter-Lock file tubes can be stacked right to the ceiling, or installed around existing files . . . saving space yet with complete accessibility.

SAVE TIME

Drawings are easy to file and find . . . with indexing right on the file door, and cone-shaped front for fingertip drawing removal.

PROTECT DRAWINGS

with dust-proof, light-tight, crush-proof, and fire-resistant Inter-Lock files.

SAVE MONEY

Initial cost is low, and many firms purchase Inter-Lock files in quantities that can be written off as "supplies" rather than "office equipment."

Send TODAY for descriptive folder and prices.

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PE

Great advances in design . . .

NEED THE ADVANCEMENT IN WEAR RESISTANCE PROVIDED BY FLAME-PLATING BY LINDE

Lockheed's F-104A Starfighter, newest weapon of the Air Force, is the most advanced airplane of its type. To give them the greatest possible resistance to extreme conditions, bearing surfaces *(arrows)* of hot air valves used in the F-104A are Flame-Plated with tungsten carbide. Flame-Plating provides the wear-resistant coating needed to withstand the high unit loading and temperature extremes jet plane parts undergo.

Stratospheric altitudes . . . supersonic speeds . . . extreme temperatures subject jet plane parts to almost incredible conditions of heat and abrasion. To assure perfect operation in all circumstances, bearings of hot air valves in the Starfighter are Flame-Plated. A tungsten carbide coating, applied by LINDE's unique method, is the only material tried that successfully eliminated galling and provided a low coefficient of friction over the required service life of the part. With the part Flame-Plated, practically no wear occurred. This LINDE process is now a regular production procedure.

Flame-Plating is LINDE's special process for protecting metal parts from wear, abrasion, and fretting corrosion. Tiny particles of tungsten carbide or aluminum oxide are literally *blasted* onto the metal surface. Since the temperature of the part being coated seldom exceeds 400 degrees F., there is little or no risk of changes in its shape or metallurgical properties. Flame-Plated coatings can be applied from .002 to .010 inches thick, and used as coated or finished to 0.5 microinches rms. Practically all metals can be Flame-Plated—aluminum, magnesium, molybdenum, titanium as well as copper and steel.

Your own design may be improved by Flame-Plating. Find out how, by writing for a copy of the booklet "Flame-Plating," F8065. Address Flame-Plating, Dept. P-15, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

In Canada: Linde Company, Division of Union Carbide Canada Limited.

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UNION CARBIDE

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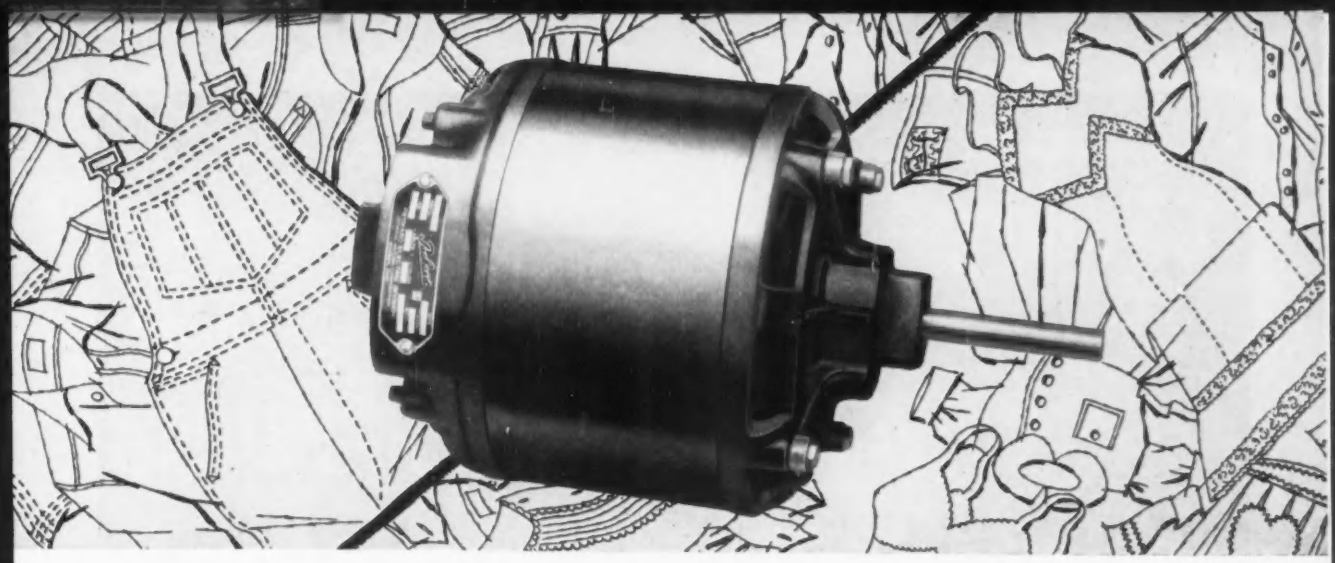
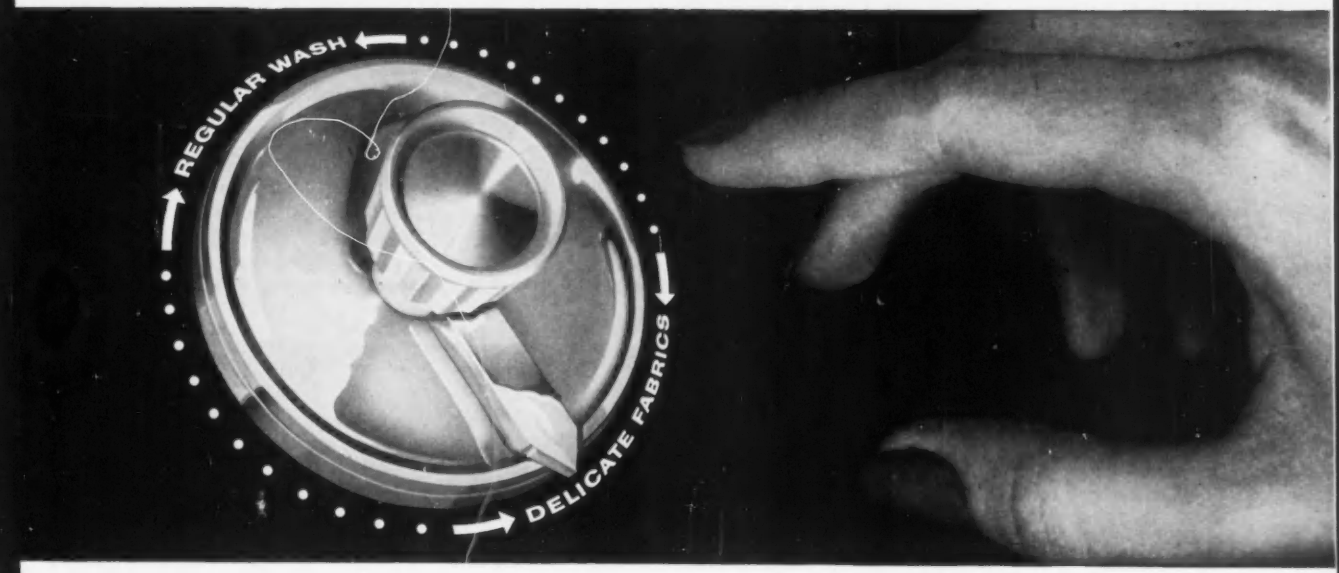


PACKARD ELECTRIC / *NEW... custom-tailored washing machine motor*



FHP MOTORS / *Provides power for two washing speeds... electrically!*

It's an old idea based on need. Make the agitator speed variable. Then, both light and heavy clothes could be thoroughly washed without harming fabrics.

There were no two-speed appliance motors available with enough power at both speeds. Mechanical means, such as gears, belts and pulleys, clutches, etc., cost too much, took up too much space, made too much noise and caused too many maintenance problems.

A Packard Electric motor engineering team was first to solve the problem with a compact, two-speed unit that had just the amount of speed, power and torque required. And washing machine manufacturers who worked out the solution with Packard Electric engineers have had a big competitive advantage ever since.

What's more, there are further savings in assembly when you buy Packard. That's because Packard will deliver a motor complete with special mountings and accessories to simplify your assembly procedures.

Packard Electric research and engineering teams have a long record of accomplishment in the custom-built motor field. And, even now, new ideas are on the boards to help our customers produce better, lower priced products for the appliances of tomorrow.

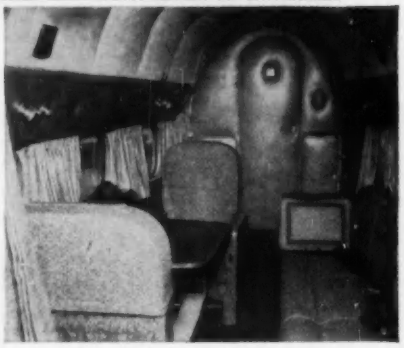
Packard Electric

Warren, Ohio GM GENERAL MOTORS

Division of General Motors

In these ways:

For relaxable cushioning, soft to the touch, yet not bouncy.



As padding for bulkhead and doors, carpet underlay and seating.

Because of these advantages:

So tough it hog-rings to seating springs without backing support or fabric liners.

Elasticity, durability and structural strength unmatched by any other foam material.

... Plus Functional Utility ...

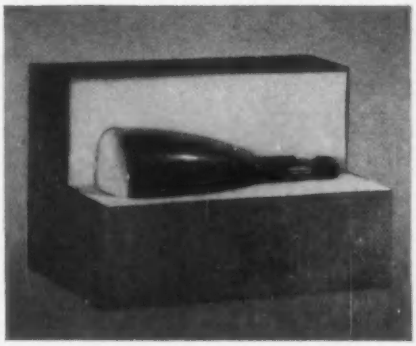
In addition to the above uses, industry leaders are specifying urethane foam for sound and thermal insulation, underlay, footwear, sporting goods, household items, and dozens of other uses because it can be heat-sealed, hot-wire or die-cut, flocked and colored; it's shock-absorbent, density-controllable, resistant to cleaning chemicals, soaps, fire, mildew, heat, cold, abrasion.

Join the leaders! If your products call for cushioning, padding or insulation, you can improve their design, lower costs and expand your markets with urethane foam. Remember sales rule #1: "If you wait 'til your customers ask for it, they're already shopping elsewhere."

and more

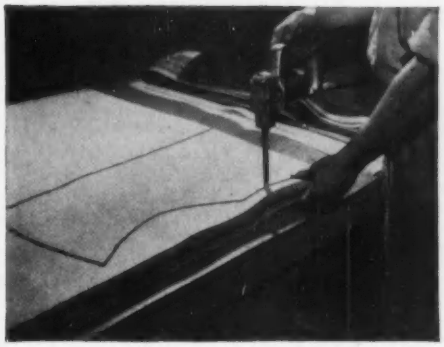
FOAM is being used

As supple, lightweight interlining for outerwear.



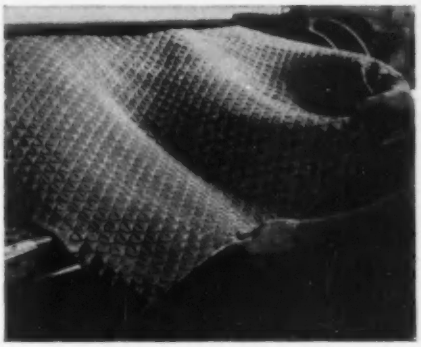
As economical protection for shipment and storage of precision equipment.

Molded safety dash panels and sunvisors for shock absorption and cushioning.



So easy to fabricate, it cuts with ordinary scissors or power-driven pattern cutters.

Feather-light, shock resistant —a wide range of densities, resiliencies and toughness.



Slices so thin it has the drape and feel of velvet . . . quilts to fabrics with standard equipment.

Mobay is the leading supplier of quality chemicals, product development and technical assistance, to manufacturers of urethane foams for industry. Write today for sources of supply and further information.

MOBAY

First in Urethane Chemistry

Mobay Chemical Company
Dept. P-3
St. Louis 4, Mo.

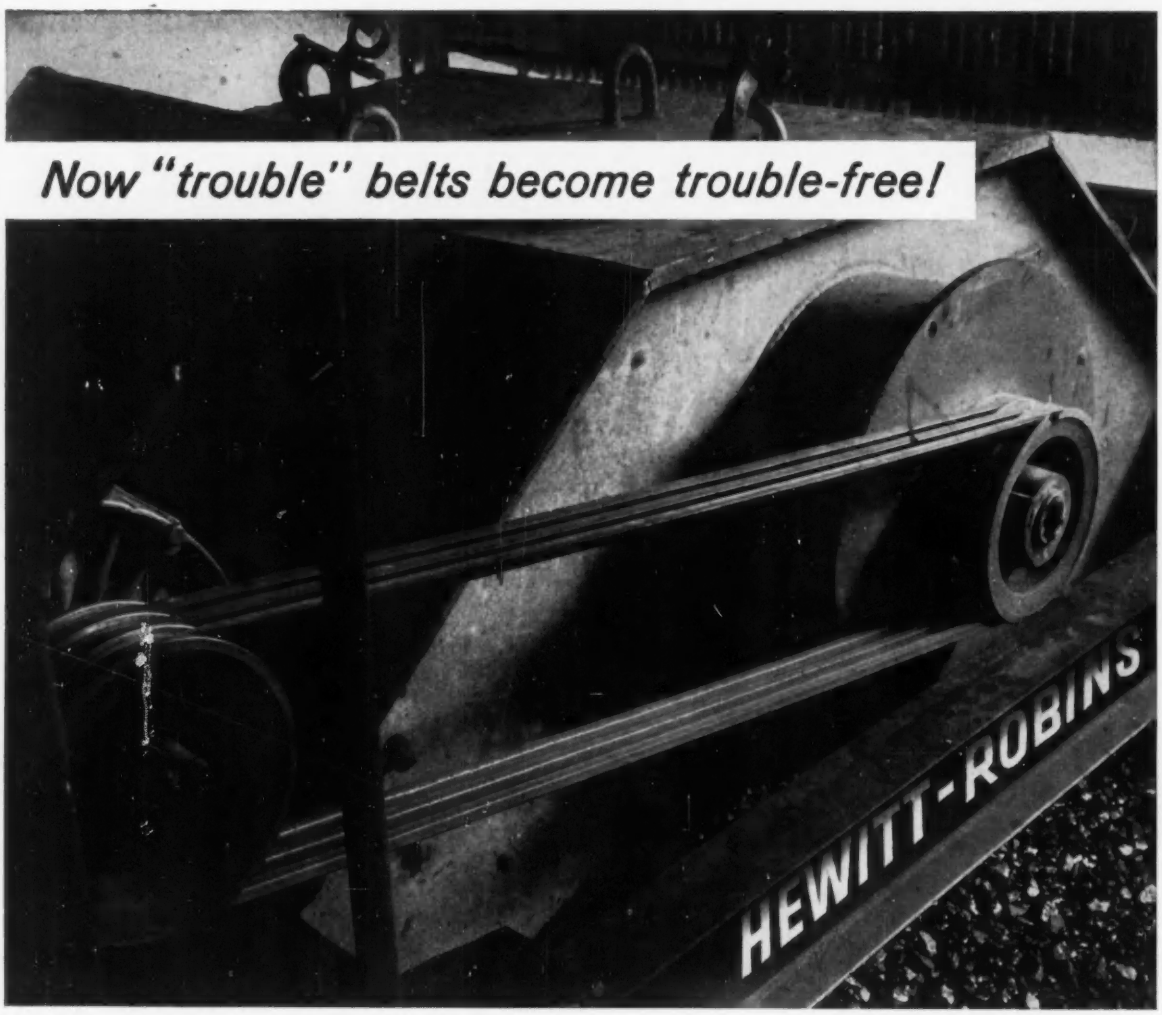
Please send literature on flexible urethane foams ☐

Please have representative call on me ☐

Name _____

Address _____

_____



Now "trouble" belts become trouble-free!

INDIANAPOLIS POWER & LIGHT COMPANY REPORTS:

Premium V-belts reinforced with DACRON last 52 times longer than ordinary V-belts on coal unloader

REG. U. S. PAT. OFF.

The Hewitt-Robins Car Shakeout in the receiving yards of the Indianapolis Power & Light Company needed new V-belts about every three weeks before its drive was switched to V-belts reinforced with "Dacron"*. In five years' operation only one belt change has been necessary—after three years' use. Despite the rugged operating conditions involved in unloading up to 30 hopper-car loads of coal a day, these belts made with Du Pont "Dacron" lasted 52 times longer than belts reinforced with conventional fiber.

The machine that uses V-belts reinforced with "Dacron" gets up to 40% more horsepower from its belt drives than is possible with other reinforcing fibers. The ability of these belts to withstand greater shock loads coupled with their longer flex life results in remarkable durability. They stretch less and are more stable than other belts . . . require far less maintenance. And design men find they can use fewer and smaller belts and sheaves, to meet today's demand for more compact, more economical belt drives.

For the next drive you design or install, consider the advantages of premium V-belts made with "Dacron". They combine the unique properties of "Dacron" polyester fiber made by Du Pont and the highest skills of leading manufacturers who make the belts. E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Department, Wilmington 98, Delaware.

**"Dacron" is Du Pont's registered trademark for its polyester fiber.*

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

V-BELTS OF "DACRON" transmit more horsepower . . stand greater shock loads . . . give longer flex life . . . give greater opportunities for machine-design improvement.

Here is the KEY to higher VOLUME PROFITS through BETTER ACTUATION!

FREE!

NEW 1958 ENGINEERING DATA BOOK and STANDARD ASSEMBLIES PRICE LIST

from world's largest producer of b/b screws and splines

7 LOW-COST STANDARD SIZES

36-page book is crammed with helpful facts on b/b Screw Basic Operation • Applications • Advantages • Features Characteristics • Technical Data • Standard Assemblies Couplings • Design Data • Engineering Assistance • Service. Make your volume products easier to produce, operate and sell with Saginaw b/b Rolled Thread Screws—they cost no more and are far more efficient than acme screws!

Saginaw b/b ROLLED THREAD Screws

standard assembly

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

SEND FOR YOUR FREE COPY TODAY

Saginaw Steering Gear Division, General Motors Corporation
b/b Screw and Spline Operation, Dept. 4PE,
Saginaw, Michigan

Please send 1958 engineering data book on Saginaw b/b Screws and Splines, and standard assemblies price list, to:

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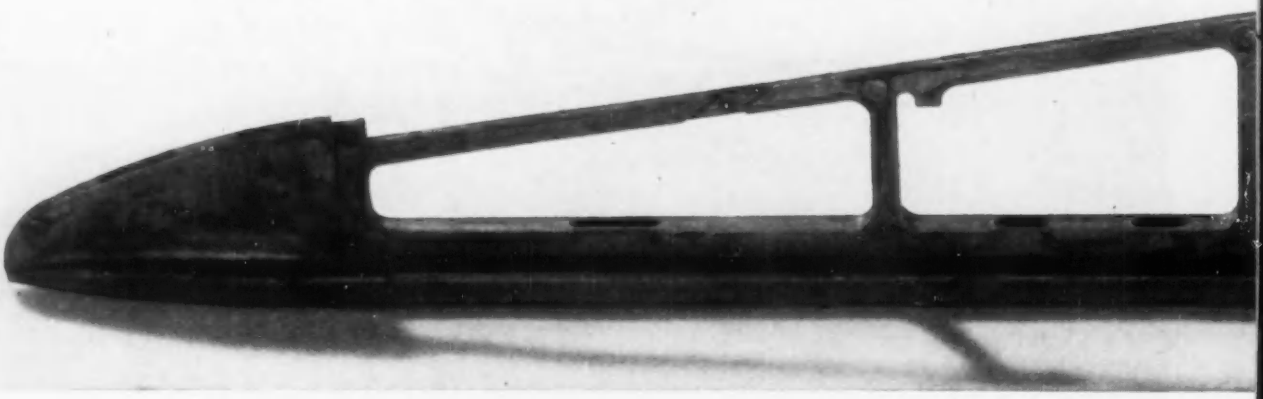
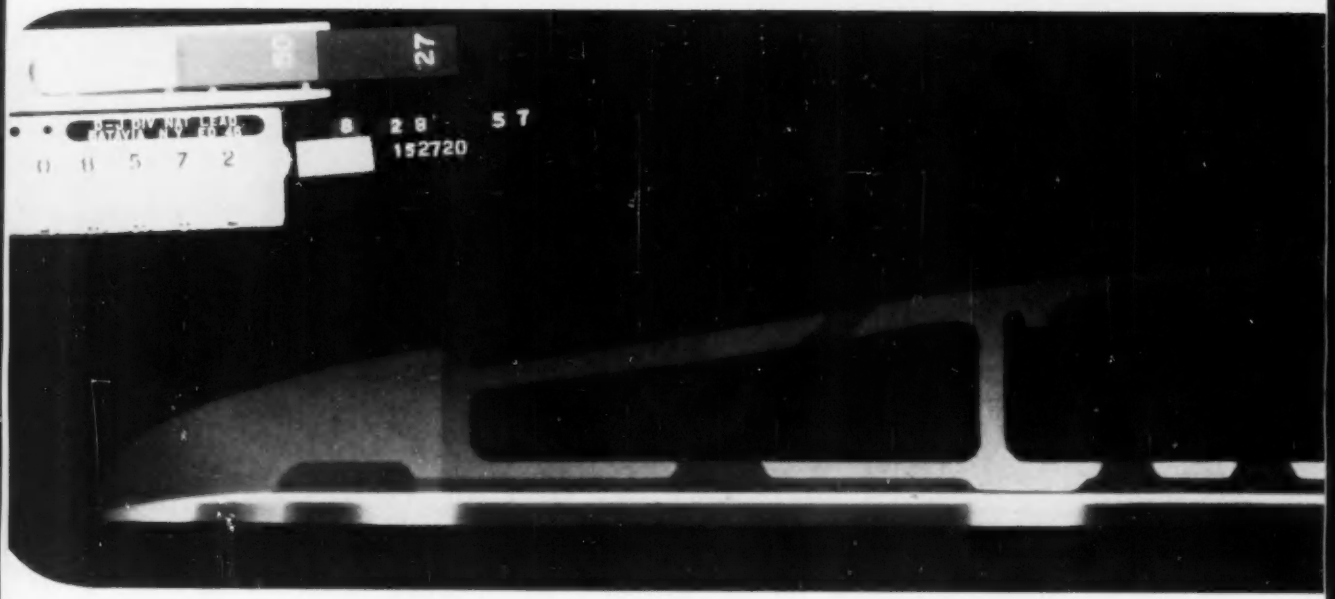
CITY _____ ZONE _____ STATE _____

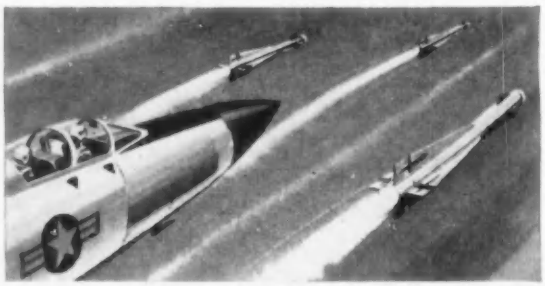
overall length 42 inches



Now...from Doehler-Jarvis...die castings



X-ray of the Falcon's fin proves



The Falcon is an air-to-air missile built by Hughes Aircraft Company for the U. S. Air Force. Its light weight die cast stabilizer fins resist severe strain during course changes. It uses other Doehler-Jarvis die castings also.

Now *you* can have structurals die cast to standards as high as those for primary aircraft structurals*.

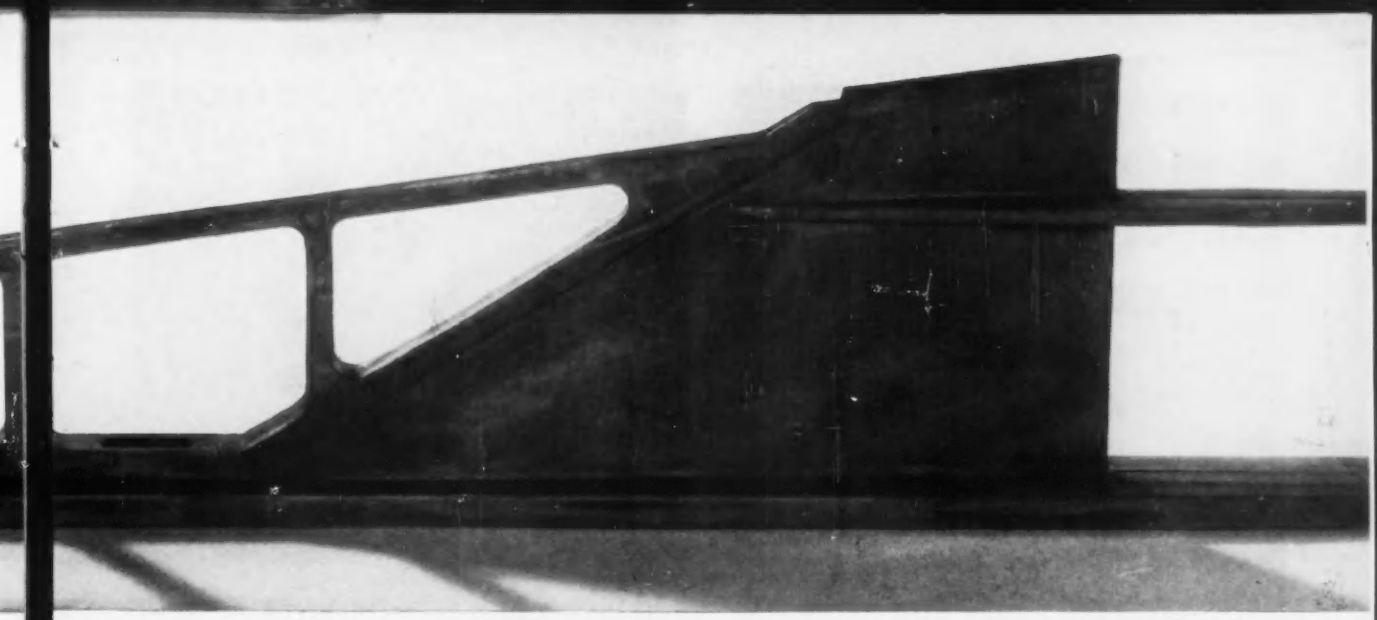
Die cast! With all the economy, precision, surface superiority, ease of assembly that implies. Die cast of aluminum, or of a high-purity magnesium alloy, like the 42" Falcon stabilizer fin.

They said it couldn't be done!

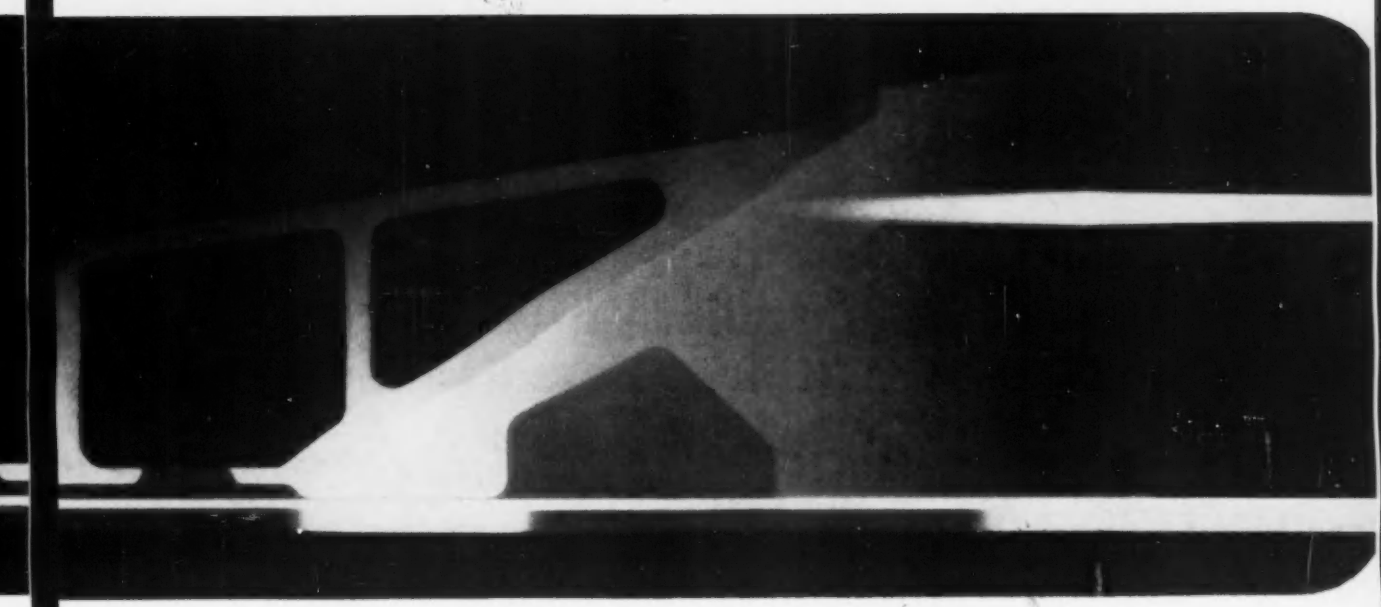
But there you see such a structural! Along with X-ray proof of soundness, uniformity, primary-aircraft-structural* quality.

Mind you! The Falcon fin is in commercial production. Doehler-Jarvis has die cast thousands. Each has had to pass 73 inspections before acceptance . . . including 100% X-ray.

In *one* control, sections of castings are continuously tested for tensile strength. In this examination of physical properties, the castings normally exceed tensile specifications by 15% or



# of primary-aircraft-structural* quality



their uniformity and soundness

more. Quality is so high there has never been a single test below specification.

How did this come about?

Like many developments in die casting, this one started with a customer's need . . . Hughes Aircraft's.

They, and the Armed Services, needed such castings. The parts *might* be made other ways. But at what cost! What sacrifice in weight — and materials! If it *could* be die cast, if there *were* a magnesium alloy able to stand supersonic air stresses . . .

It took a while. But, with close cooperation from engineers of both Doehler-Jarvis and Hughes, the way was found.

Now you can list die castings of primary-aircraft-structural* quality among D and J availabilities. Get them from any Doehler-Jarvis plant.

*A primary aircraft structural is a major load-bearing component member any single failure of which would result in loss of the aircraft.

Doehler-Jarvis

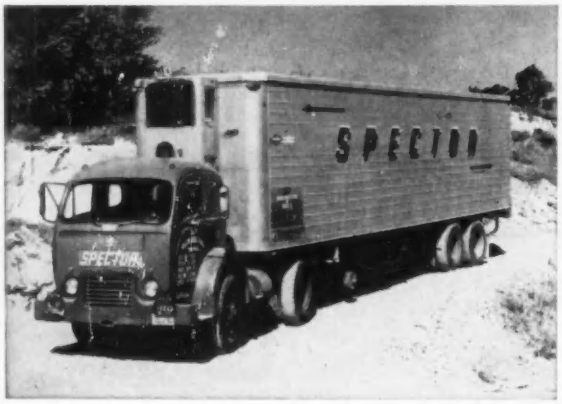
DIVISION OF NATIONAL LEAD COMPANY

General Offices: Toledo 1, Ohio

In Canada:

Barber Die Casting Co. Limited

Hamilton, Ontario



Profit-minded fleet operators choose White Trucks equipped with long-lived BLOOD BROTHERS Propeller Shafts

Whatever the job, construction work or highway hauling—profit's the motive. And on White trucks, dependable components like Blood Brothers Propeller Shafts give fleet owners extra profit protection.

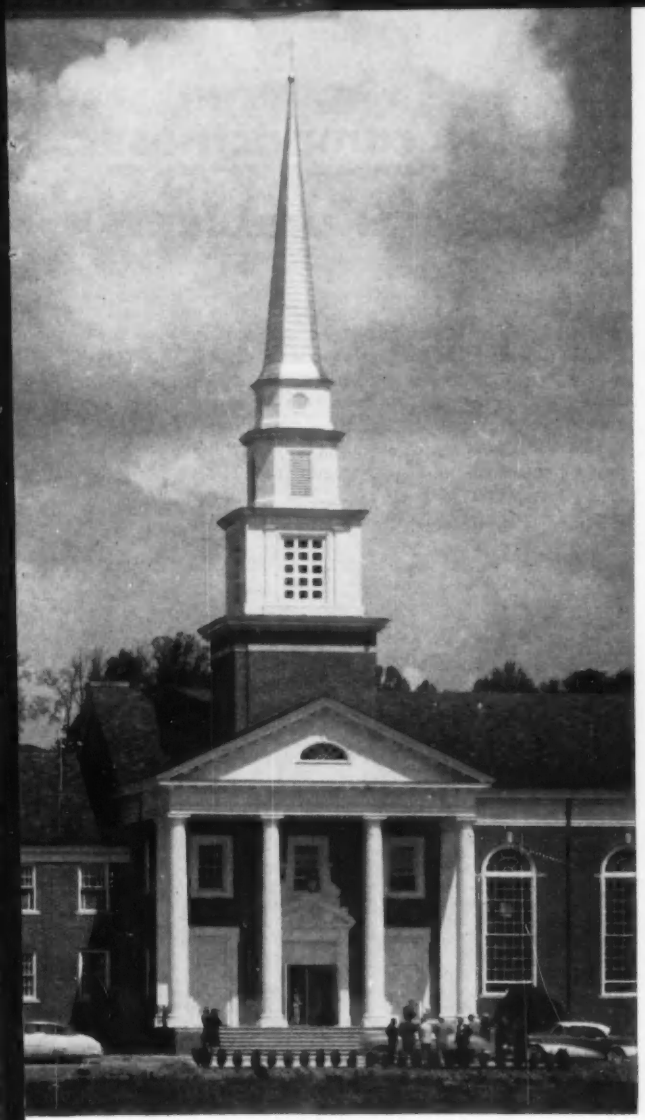
At highway speeds, precision balanced Blood Brothers Propeller Shafts deliver maximum torque smoothly—with minimum vibration. On off-the-road jobs, they stand up under the sudden shocks and strains of the most demanding service.

That's why for today's high horsepower engines, White and others depend upon Blood Brothers Propeller Shafts.

If you have a propeller shaft problem, look to Blood Brothers. Our engineering department will be happy to make suggestions.

BLOOD BROTHERS MACHINE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES



NOTHING *can equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

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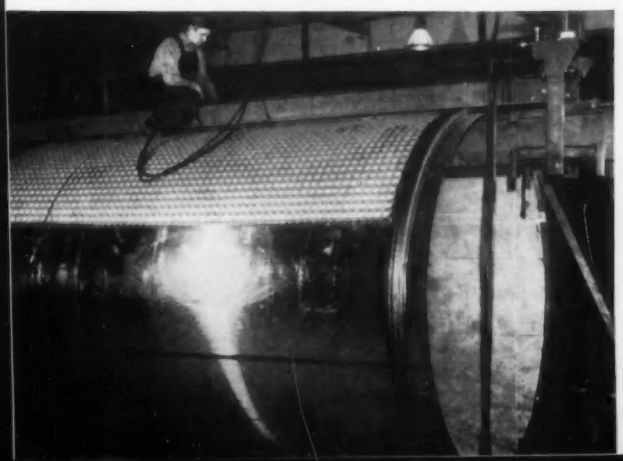
USS

UNITED STATES STEEL

FOR BEAUTY. Stainless Steel shingles in diminishing sizes create a beautiful, gleaming steeple for the State Street Methodist Church in Bristol, Virginia. Architect Allen Dryden, of Kingsport, Tenn., specifies Stainless Steel for jobs like this to assure lasting beauty, protection from weather and freedom from maintenance. This spire is sheathed in Type 302 26-gage Stainless Steel, and the cross is built of Type 302 Stainless bars. Construction details were engineered by Overly Manufacturing Company, Greensburg, Pa., who also fabricated and erected the steeple.

FOR FLEXIBILITY OF DESIGN. In this "Cold-Zone" cooling-storage milk products tank, made by Damrow Brothers Company, Fond du Lac, Wisc., Type 304 10-gage Stainless Steel was used for the smooth, easy-to-clean inner wall. Again Stainless Steel—this time Type 304 16-gage—was used for the dimpled outer wall which is stave-welded to the inner shell. This unusual design of dimple size and arrangement gives proper baffling and velocity to the refrigerant as it passes through the cooling area. Stainless Steel provides greater sanitation, durability, long life, strength and—the flexibility necessary to make this design possible.

FOR DURABILITY. The Master Combination Padlock, designed for school locker room use and built by Master Lock Company, Milwaukee, Wisconsin, features a double-case construction—with Type 430 Stainless Steel used for the outer case. This Stainless Steel design makes it one of the strongest padlocks available. In addition to increasing the lock's durability, Stainless Steel also adds to its sales appeal and to its resistance to the corrosive atmospheres of damp locker rooms. The springs, too, are made from USS Stainless Steel—Type 304 Ameroxide coated wire.



how ASCO solenoid valve compactness solves SILEX control problems

Is limited space a problem in your design? ASCO 2-Way Bulletin 8210A Solenoid Valves can save you critical space—just as they have in the compactly designed "Silex Coffee Maker." Here three ASCO valves were crammed into an extremely limited area: a drain valve which flows hot water into the brew tank; a decanter valve which channels brewed coffee to the dispenser and the 8210A which releases cold water to flush out coffee grounds. The 8210A valve used measured only 3 13/16" in height; 2¾" face to face.

Here is what Silex Project Engineer, H. M. Voglesonger, had to say about the 8210A: "The compactness of the ASCO line of solenoid valves makes them ideal for the close quarters required in the internal construction of our Silex Coffee Brewers. The 8210A valve and the two specially designed valves we have selected have proved extremely reliable; after a year of operation under the most severe conditions, we were thoroughly satisfied with the product quality. ASCO 'Engineering Service'—the extra help provided by the ASCO Engineering Staff – made the successful manufacture of the equipment possible."

Bulletin 8210A valves are available in pipe sizes up to 3"; pressures to 350 p.s.i.– in standard, watertight or explosion proof enclosures. Fluids handled include air, gas, water, light oil and other non-corrosive liquids or gases. If you have a flow control problem involving any fluid—corrosive or non-corrosive—check on the advantages of these ASCO qualities: compact design, dependability in action and cooperative "Engineering Service." Write for complete details.

Write for Catalog 201 covering complete line of ASCO solenoid valves

Automatic Switch Co.
54-G Hanover Road, Florham Park, New Jersey
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ASCO

PERSPECTIVES

in design and development . . .

What's Ahead for Business in 1958

In general, 1958 will be a good year for business, according to a new report from the McGraw-Hill Economics Department. In fact, with the help of some more price increases, the total dollar volume of business should be higher than it is this year. But beating this year's volume will be hard because business plans to cut spending by 7%, compared with 1957. Investment by manufacturing companies will be down 16%.

However, using only 1957 for comparison will give a somewhat distorted impression. For example, investment in 1958 promises to be higher than that of any year before the start of the present investment boom. Take 1955, a year in which investment was not down, but extremely high. In physical terms, it appears that next year's planned investment in new producing facilities should be about 10% higher than in 1955. In dollar values it should be 20% higher.

Reason: Past Buildup of Manufacturing Facilities

This is the first time since 1954 that investment in new plants and equipment has been down. The reason is the recent build-up in manufacturing —the area to be hit by the investment decline. This build-up was shown in recent surveys. According to last year's report, capacity at the end of 1957 will be up 13% since 1955. But production has shown almost no increase. The new survey reports manufacturing companies operating at about 82% of capacity, a drop from 92% at the end of 1955 and 86% at the end of 1956. Manufacturing companies want an average rate of 90%, so this let-up in expansion rate avoids a dangerous excess.

It figures then, that industry men are not going to allow a surplus of facilities to develop. Expansion programs and construction schedules are being stretched out to allow for a more orderly adjustment of potential productive capacity to actual production. This is necessary because, for the first time since World War II, manufacturing capacity generally is adequate, or more than adequate, and all types of manufactured goods are in ready supply.

The Classical Cycle Doesn't Follow

According to an old investment cycle theory, 1958's 7%-spending drop will start a decline that should accelerate to 15-20% in 1959, and go still lower after that. But this is not likely to happen.

Don't Forget Sputnik and Muttnik

Russia's launching of her two globe-circling satellites has an important bearing on the business outlook. The "moons" spotlight our science race with Russia, and in the long run will mean great development programs to increase our stature in science and technology.

In the short run—months, that is—Sputnik will slow the scheduled cuts in defense spending. One of the first moves in this direction was the reinstatement of nearly $200 million for research and development lopped off in August.

The Facts of Life in Today's Business

Intelligently managed firms have to work hard to cut costs and maintain competitive pricing. It is hopeless to expect that costs can be reduced by the cooperation of labor in foregoing wage increases. It is more likely that wages will continue to advance at a rate that will be difficult to match in terms of productivity. Only continuous investment

(continued on page 69

Special Bolting Requirement?

USE A SPECIAL FASTENER

The range of Bethlehem standard fasteners is wide enough to handle most bolting requirements. But quite often a special job calls for a special fastener, one designed to meet a specific need. Special fasteners are likely to be the economical answer, especially when the quantity is large enough to absorb the cost of special tools and machine set-up.

We're old hands at designing and producing fastener "specials." At Bethlehem's modern plant in Lebanon, Pa., we're constantly turning out the unusual in headed and threaded products. Our fasteners engineers are often able to improve on the design of the bolts you're now using. But not always. When a special fastener is not practical, we'll say so frankly.

So whether you need standard or special fasteners, let's talk it over. We'll gladly study the problem and make our recommendations. Just get in touch with the nearest Bethlehem sales office, or write to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY
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BETHLEHEM STEEL

BETHLEHEM STEEL

in cost-cutting equipment will keep productivity advancing with wages. Business will be straining to expand markets in the next three to five years. The key to these markets is new products—which often require a large capital outlay. The survey showed that by 1959, about one-third of all manufacturing firms plan to make substantial capital expenditures to bring out new products. This proportion will increase steadily.

Look for big advances in product design and development. The huge sums (about $7.3 billion this year) invested in research and development bear this out. This figure is up some 20% from last year's $6.1 billion. This past spring, industry had plans to carry out almost $9.3-billion-worth of R & D in 1960. The new survey shows that while there will be a decline in capital spending in new plants and equipment, most companies intend to spend at least as much for research in 1958 as they spent in 1957.

New Materials Force Changes on Manufacturers

The development of new materials, machinery and manufacturing process will, in the next five years, force design changes on manufacturers. But the manufacturers will have no choice if they hope to keep up with competition. For the most part, these new materials and designs will increase product quality and lower direct labor cost. But they will also require new capital—in large amounts where new processes are involved. Consequently, there will be no lack of investment incentive. It is expected that industry will spend all of its depreciation allowances, and all of the earnings it can retain for some time to come, on new, improved plants and equipment, and on special tooling for new products.

Summing Up

We're in for a breather. There will be a period of active investment and high capital requirements, but the pressure in 1958 will not be as strong as in 1957. For the long-range planner, set your sights on 1960. By that year, investment in new plants and equipment will probably be up again, and heading for another record.

Another Viewpoint

Tax relief, early easing of credit policies, or some similar new force must be put into operation to better business prospects for 1958, or the situation will continue to weaken, according to Martin R. Gainsbrugh, Chief economist, National Industrial Conference Board. Speaking before the 12th National Membership Meeting of the National Tool & Die Mfrs. Assn. at the Edgewater Beach Hotel, Chicago, Nov. 1, he pointed out that key indicators are dipping, although the gross national product is continuing to rise.

Goods and services were up almost 6% in 1956, half a real advance; the other half, price increases. The first half of 1956 showed a similar increase, but price rises were more pronounced. Manufacturing output has sagged about 2%. Capital-goods production is off more, but the output of non-durables, hitting a high in September, is holding the total up. Consumer expenditures for non-durables show the greatest rise.

Factory employment was down in September, but total non-farm employment was up—led by insurance, financial, trade, construction, and state and local government. Total employment was 750,000 above last year in September. Four forces which had held employment up are all now weakening, appropriations for new plants and equipment are declining, exports are down, but consumer buying and state and local government spending are still rising. —PAUL ANDERSON

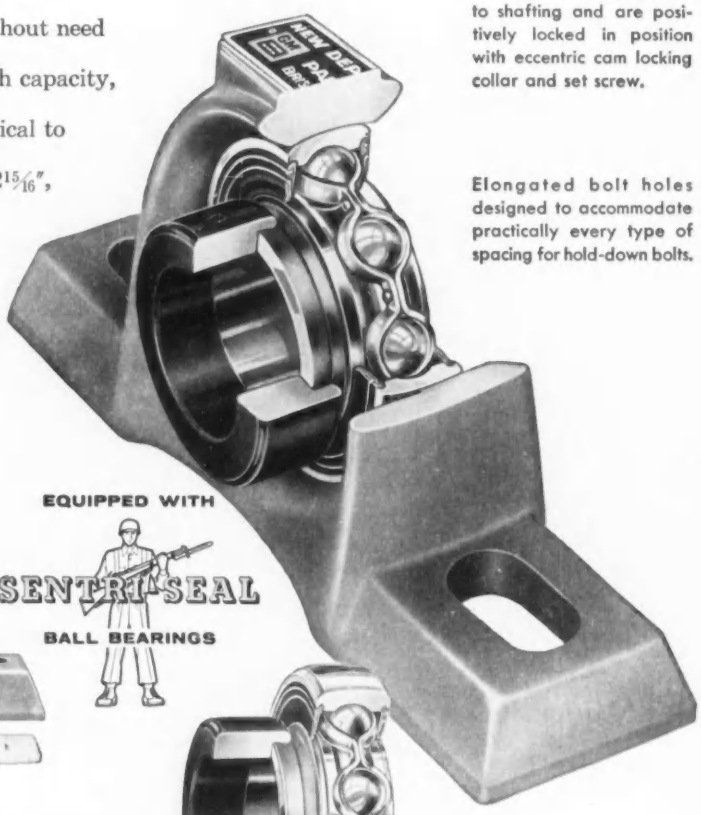
ND FACTS

NEW DEPARTURE PILLOW BLOCKS— BUILT FOR LOWEST MAINTENANCE

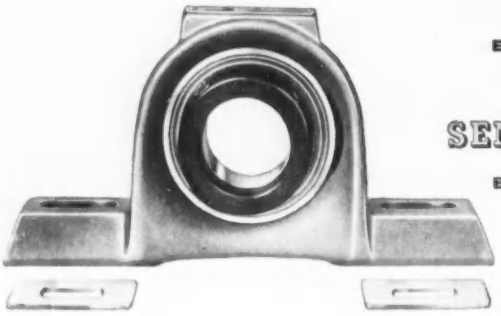
- New Departure adapter ball bearings are sealed and lubricated for life.
- Design is compact and rigid—fits easily in limited space.
- No grease nipples or other protruding lubricating fixtures needed.
- Pillow blocks are easily mounted without need for any special tools.
- New Departure ball bearings are high capacity, precision-built for long life.
- Bearing and block surfaces are spherical to accommodate any misalignment.
- Thirty-two shaft sizes, $\frac{1}{2}$" through $2\frac{15}{16}$", for wide variety of applications.
- Interchangeable with most other makes of pillow blocks.

Bearings are easily applied to shafting and are positively locked in position with eccentric cam locking collar and set screw.

Elongated bolt holes designed to accommodate practically every type of spacing for hold-down bolts.



Mounting pads are furnished with each New Departure Pillow Block to assure easy interchangeability with all pillow blocks having a high base-to-center dimension.



EQUIPPED WITH

BALL BEARINGS

New Departure Pillow Blocks employ performance-proved Type AE adapter ball bearing with Sentri-Seals for long-life protection against dirt or grease leakage.

Send for Catalog PBC

1908–1958 GM FORWARD FROM FIFTY

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Product Engineering

November 25, 1957

don't tense!

These two words, popular advice on American campuses a few years back, are still the best suggestion anyone can offer to the scientist or engineer who wants his words to be understood by every hearer or reader. Yet he can scarcely help tensing a little every time he speaks or writes, because the layman now hangs on his words.

Atom bomb, H-bomb, *Nautilus*, ICBM, and now the sputnik—these, coupled with less-spectacular products like automation, pushbutton plants and homes, have awakened every layman to the accelerating pace of technology. Life and livelihood are at stake—or appear to be—so everybody wants science and engineering explained in words of one syllable.

What's more, the explanation is assumed to be final and definitive, regardless of the relationship of the subject to the scientist's or engineer's special skill or area of knowledge. So millions of pointless and trashy words appear in lay publications, on radio and on TV, "interpreted" by reporters in search of a headline or presented by publicity-seeking professional people. The whole business is reminiscent of the train-platform interviews with movie stars on life, or with arriving foreign visitors on their opinions of American cities or women. Apparently the medical profession knew what it was doing years ago when it in effect muzzled its own members in public.

An odd off-shoot of this sudden scientific binge is continuous urging in the lay press for engineers to talk and write like people. The *Saturday Review* asks scientists to admit they're human. *The New York Times* waggles an editorial finger at a scientist's explanation of how to pace the sputnik. *The New Yorker* pokes fun at "miniaturization" and similar coined words.

Some of the terminology of engineering and science is necessary for precise understanding, some is coined to impress the unwary, some is simply slang for intercommunication between fellow workers. But a great deal is unnecessary in public utterances and serves only to draw critical attention—perhaps generated by the urge to "stand tall" in the public eye, just as some men grow beards or wear off-standard suits. This urge is always with us, and is certainly understandable. It is harmless unless the user is taken seriously.

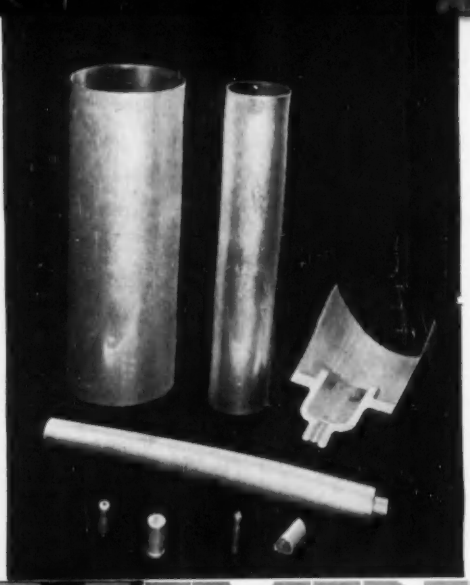
The point is that everything a scientist or engineer says or writes in these uncertain times is likely to be taken seriously. But this is no reason for trotting out the gobbledegook, nor for rushing in with irresponsible judgments on subjects foreign to the judge's experience.

It's better to use plain English on subjects you know about, and have no words at all on those you don't. That policy avoids tension, and does the profession—and yourself—a service.

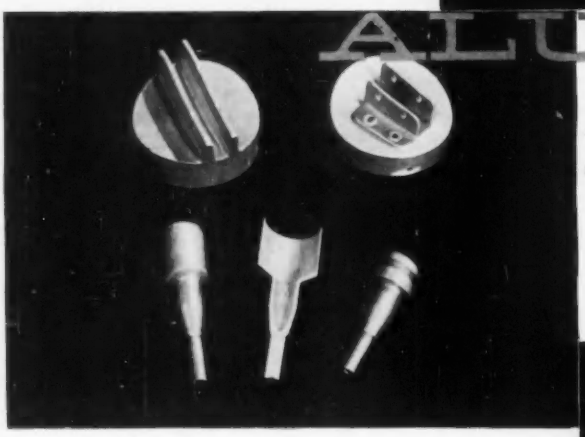
K. S. Tangerman

Advances
in tooling now offer
- larger ratios
- thinner walls
- smaller parts

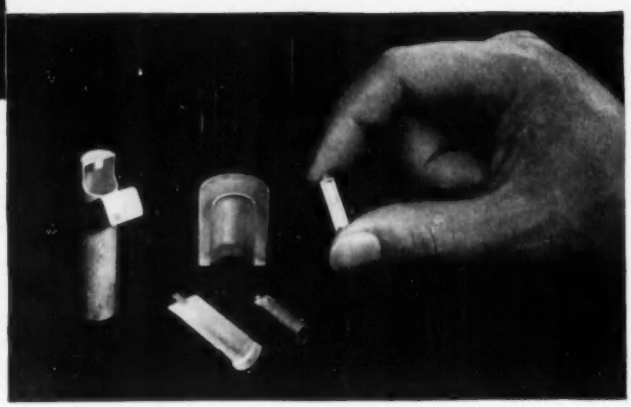
in . . . . .



ALUMINUM IMPACT



Composite part . . .
(top, left) replaces seven-piece assembly (right) with one impact extrusion. Cheap aluminum extrusion shown as part and section (bottom) replaces brass part (right) made by automatic screw machine.



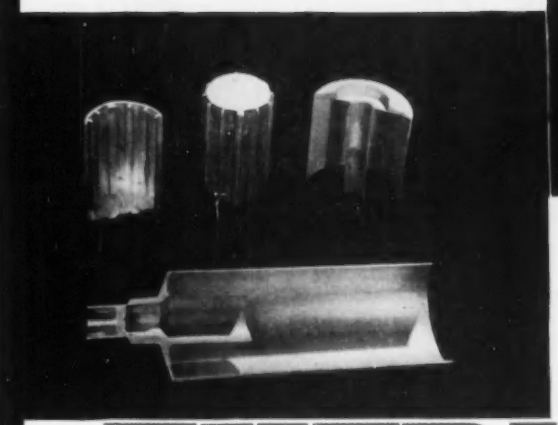
Miniature parts . . .
with OD no more than 3/16 in. can be made with length-to-dia ratios as high as 8:1.

Wider ranges of OD, length and wall thickness are now possible using hydraulic presses and better tool materials.

Recent advances in tooling widen the size range of parts that can be made by impact extrusion—the most economical method of producing a seamless cylinder with a closed end. This is particularly true when the material is aluminum. Parts are no longer limited to 5-in. dia . . . length-to-dia ratios have been increased two-fold . . . the harder tools available allow extrusion of thinner walls than formerly.

Result—the method need no longer be confined to producing a few simple shapes such as collapsible tubes, radio-capacitor housings, and tube shields. Even before the new developments, full capabilities of the process were not always realized. But now, aluminum impact extrusions can be specified in even more design areas.

Impact extrusion offers a high production rate, little waste; it gives parts with close tolerances, good concentricity, and good mechanical properties. Tooling is simple, with only about two weeks between design and production of finished parts.



Integral flutes
locate laminations in these motor armature and field parts. Note also the thin double wall combined with extreme variation in thickness.

End shapes . . .
can be extruded in unlimited variety to give connecting rods, lettering, wrench sockets, and basses.

EXTRUSIONS

NICHOLAS MARCHAK
Director of Research and Engineering
Sun Tube Corp.

This is a process that easily produces all types of closed cylinders in the true geometric sense—rectangular, triangular, round, polygonal, or other irregular shapes with parallel sides. The closed end can be made with an unlimited variety of shapes and bosses on the inside or outside. These shapes can be used as nozzles, locating bosses, printed lettering for directions, and turning lugs. The integral, closed end is leakproof and eliminates necessity for secondary crimping, sealing, and soldering. Fluting can be formed on both the exterior and interior: for a part gripped by hand; to locate punched laminates for motor windings; to allow a spiral screw action.

NEW DIMENSIONS

Parts can be larger than 5-in. dia now—hydraulic presses give a sufficiently high pressing force without imparting excessive impact to the punch.

Length-to-dia ratios were formerly limited to 6:1. They can now go up to 14:1 because of the higher-strength material used in punches which are stiffer, so can withstand higher forces without bending. Hydraulic presses give the longer stroke needed for longer parts.

Thinner walls—down to 0.004 in.—are now made by harder tools which do not wear rapidly when used with low clearances. Stiffer punches can be centered more accurately in relation to the die—for both close tolerances and thin walls.

Miniature parts of $\frac{1}{16}$-in. dia are now possible because better tool material allows slender punches and dies to withstand the necessary impact forces. Extrusions are being produced with a ratio of 8:1 in this small size, in both circular and noncircular shapes.

THICKNESS HAS LIMITATIONS

Max wall thickness is about $\frac{3}{4}$ in., but such heavy thicknesses are limited to large-OD shapes, about 3 in. or above, to give the punch sufficient diameter to prevent it from buckling under the impact loads required.

Tool wear increases with decrease in wall thickness, and when this thickness goes below 0.004 in., more frequent replacement of tools offsets the cost advantages of this process.

Max bottom thickness is limited only by the block die depth, and capacity and throw of the press. At initial contact of the punch, the metal is deformed and compressed: elastically first, then plastically while it is being extruded. Min bottom thickness is about two times wall thickness, although additional metal can be provided for bosses, sockets, lettering etc.

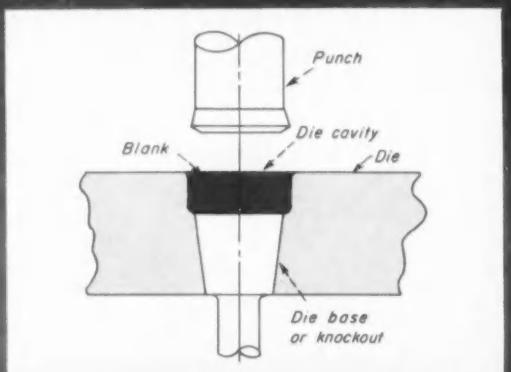
ADVANTAGES

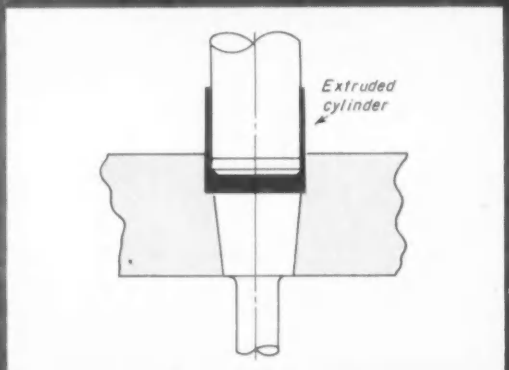
Rapid delivery of finished parts is a strong advantage of the process. Compared with drawing, done in multiple steps and requiring expensive and multiple tools, impact extrusions are formed with one stroke and minimum tooling. Standard cylindrical cans, such as those required in the electronic field, are produced with a simple cylindrical punch and die usually carried in stock. Diametral tolerances, surface finish of tools, and concentricity of setup to provide an even-walled container, are the only provisions required for accuracy. Result is rapid production—two to three weeks for simple pieces, three to four weeks for a complex design.

Bottom designs can incorporate steps, angles, slopes, or radii. This advantage over forward extrusions allows

The Impact Extrusion Process

In this simple setup for extruding a cylinder, the metal blank is placed in the die cavity and the punch comes down with such force as to generate sufficient heat to render the metal plastic without becoming molten. With aluminum, temperature reached is about 600 F. Under pressure the metal fills space between punch and die. Result is a forging. As pressure continues, the metal extrudes through the only outlet — the narrow annular space between punch and die. It rises uniformly on the shaft of the punch, forming the walls of the extrusion. The extrusion continues flowing during the downward movement of the punch, giving a seamless cylinder, with a forged closed end, that has already been cold worked to full hardness.





lettering or other embossing to be incorporated into the tooling. Angles of more than 50° should be avoided because the high pressure they transmit to the die may cause it to crack. If round bottoms or sharp angle parts cannot be avoided, a solution is to make them from blanks with the bottom already formed.

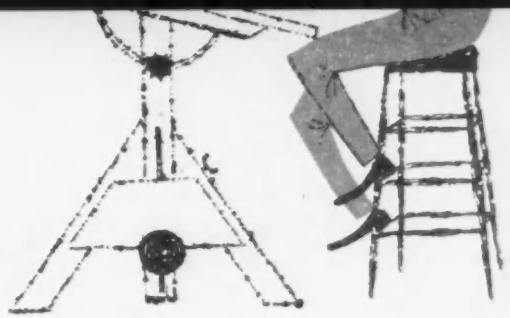
The bright surface normal on impact extrusions usually requires no further finishing. However, if supplementary operations are needed, the part must be degreased to remove the lubricant used in extrusion. The smooth surface forms a good base for other operations such as satin etching, polishing, enameling, lacquering, and lithography.

Cost of parts made by impact extrusion is low because waste is minimal and production rate is high—about 60 per min for small parts. Average number of extrusions that can be produced from a set of steel tools is 100,000 for the punch, 60,000 for the die ring, 125,000 for the die base or knockout. Renewing dies takes about 5 min; punches 10-30 min. Carbide tools are used for long runs. Economic runs begin at about 10,000 units. Smaller runs are more expensive than with other processes because the setup time is proportionally more than the production time.

Properties are improved by cold-working along the axis of the part. This gives superior mechanical properties that often eliminate necessity for heat treatment. An added advantage is the absence of machining marks perpendicular to the axis—eliminating notches which would lower fatigue resistance.

A composite impact extrusion can replace assemblies made from two or more pieces. As replacement for parts made by a screw machine, it has sufficient stiffness even though smaller amounts of cheaper materials are being used. Construction of two forged pieces can be combined, an example being pistons with piston rods. Parts can have integral names and embossed lettering without attaching name tags.

EDITOR'S NOTE: Other articles on this process: "Impact Extrusions," Apr '54, p 173, gives typical examples for different classes of impact extruded shapes; "A Closer Look at Impact Extrusion," July '54, p 129, goes further into details of the process as they affect engineers—included are data on aluminum and steel extrusions, mechanical properties, sizes, tolerances and surface finish.



ENGINEERS CAN BE FOUND — AND KEPT

G. F. NORDENHOLT
Editor of Product Engineering, 1933-1957

The current shortage is the most constructive thing that has happened to engineers—especially designers and project engineers. It has compelled industry to pay salaries more nearly in line with the value of services rendered, elevated the prestige of the engineer, and compelled management to take a closer look at the human product of the technical university. Industry has begun to contribute millions of dollars to higher education because of the indispensability of college and university.

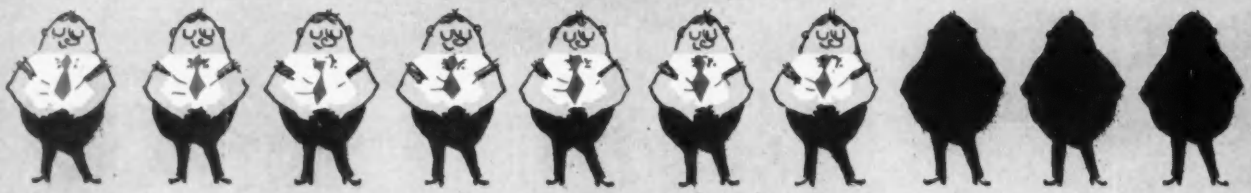
In the weeks just before relinquishing his responsibilities as Chief Editor, Mr. Nordenholt visited top executives and chief engineers in some 30 leading manufacturing companies, getting their viewpoints on this problem of selecting —and keeping—engineers. Here is what they told him, combined with some of Mr. Nordenholt's own pertinent observations.

It's about time to stop crying havoc, and to start examining the "engineer shortage" with the calculating eye of an engineer. Obviously the shortage does exist. More engineers are needed to design and produce the ever-increasing volume and variety of new products. But, complicating the problem, especially in the design field, a much higher order of education and training is required. Obvious solutions to the problem are: Produce more trained design engineers; use engineering manpower more efficiently.

But why are some companies "shorter" than others?

It is wasteful to assign work to a college-graduate engineer that can be done as well or better by a company-trained trade-school graduate. This not only deprives the trade-school graduate of an opportunity; it impels college graduates to seek work elsewhere or even give up design work. Each man in the engineering department should have the most difficult job he can handle.

For example, one machine tool company has a department of 60 to 75 designers—and only six of them are college graduates. Most of the design problems concern shapes and contours; or design for economical manufacture, operation and maintenance problems that do not need a college background in engineering. Shop experience, judgment and nontechnical relationships, plus only an elementary design knowledge, are basic requisites for a good mechanical engineer. Of course, in every design department there must be a few college-edu-



GIVE GRADUATES RECOGNITION

"Pay must parallel the responsibility and rank of the job."

"We keep more than 70% of the men we hire."

"Our turnover in the engineering department, including sales engineering and research, is little more than 5%."

"Keep the whole range of salaries in line and you will have little trouble in hiring away the best talent of the company that doesn't."

"Self-respect, pride and ego are more powerful motivating forces than the dollar."

cated engineers, or their equivalent, who will be able to solve advanced design problems.

WHERE ADVANCED TRAINING DOES COUNT

In designing products that must operate at extremely high speeds, temperatures or capacities, highly trained engineers are needed. For example, aircraft, automotive products, guided missiles, and machines that must meet exacting requirements. But in most fields of design, the "practical" problems relating to manufacturing, machine operation, and customer acceptance dominate.

At Michigan Tool, the productive value of the college graduate is limited until he has had a relatively long period of specialized and practical training. Some college graduates are not willing to take this training. During this period the college graduate has to supplement his education while the trade-school grad has been primed for just such training.

"We have trained college graduates, men from our own shop, and trade-school graduates," says Michigan Tool. "When a design problem comes up that requires 'higher design', we turn it over to a specialist best qualified, whether college graduate or not. We feel the college curriculum should contain courses in gear design."

THE TRADE-SCHOOL ANSWER

Many mechanical-engineering graduates quit a design career when they find the jobs assigned to them too elementary and not challenging. Such tasks should be assigned to trade-school graduates or mechanics being trained as designers. Turning shop men and trade-school graduates into designers is the quickest way for a company to solve much of its engineer shortage. It elevates the standing of the engineering-college graduate and the educating can be done at a reasonable cost. But the training must be done by experienced men who know how to teach.

Faced with the need for more and better design engineers, American Machine & Foundry Co. cooperated with the University of Connecticut to set up a graduate-level curriculum for training men selected by the company (Oct. 28, p. 51). Classroom space was found in a local high school. With the university administering the whole program to its customary standards, AMF engineers and scientists meeting the academic standards do the teaching.

Result: an AMF college graduate having a BS degree can obtain an MS degree in two or three years of night school. Regular university tuition is charged, but if the student earns an average grade or better, he is reimbursed the entire sum.

Besides this school, AMF has a 31-day engineer-trainee course, with lesson periods and lectures spread over a year. Subjects include drafting, accounting, details of projects research, patents, contracts and similar subjects. The company also sponsors attendance at the Oak Ridge School of Reactor Technology and sends men periodically to New York University and to the American Management Association's middle-management courses held there.

OR DO IT THIS WAY

At Reliance Electric & Engineering Co., while engineering graduates are preferred, the company has been markedly successful in hiring arts students with mechanical aptitude for engineering jobs.

Reliance only occasionally commissions colleges to undertake research. Instead, it contributes to Case Institute of Technology and Fenn College, and sponsors co-op students at Fenn. Co-op scholarships are given each year to half-a-dozen promising high-school graduates. During the co-op course, they usually work at Reliance.

How does such a program work? "The greatest worry of the new trainee is 'THEY', the ghost upstairs, until the responsibilities all along the line of management are brought into perspective. Don't just dump the trainee in his new boss' lap. Have a hiring and training group make periodic checks on what the trainee is doing and advise his boss on how to handle him."

In hiring college grads Reliance works closely with college placement officials. Reliance men who are alumni of a college are assigned to interview prospects in the graduating class. Tau Beta Pi men and members of other honorary societies are given special consideration.

But not all recruits come from colleges; some come

UPGRADE TECHNICIANS

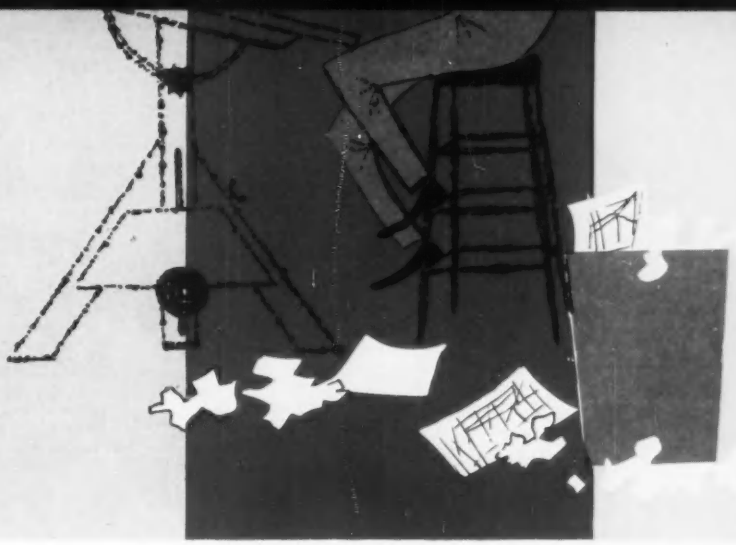
"We have trained college graduates, men from our own shop and trade school grads to become competent engineers."

"Most engineering-school grads want sales; they feel engineering is too narrow."

"Each man in the department should have the most difficult job he can handle."

"Many graduates quit a design career when they find the jobs assigned to them too elementary."

"High scholastic marks do not always assure a high degree of engineering design ability."



from competing companies. These men have heard about Reliance and have decided they would like to work for this company. Other job candidates come from employment agencies, friends of the company, or "off the street."

Men hired at Reliance receive psychological and aptitude tests plus many interviews and days of screening. The recruits are given an indoctrination of talks, lectures, minor assignments; and after a month or two are assigned tentatively to engineering, production or sales.

THE SCHOLARSHIPS APPROACH

At Sheffield Corp., special emphasis is placed on company-contributed scholarships. Since 1952, Sheffield has given 56 of them, paying practically full expenses at Northeastern University or the University of Cincinnati for 4-year co-op courses. The scholarship men take their shop work at Sheffield.

All employes and sons of employes of Sheffield are eligible. The man selects the course—metallurgy, ME, EE or business administration. Scholarship applicants must have had an average of 85% plus in high-school math and sciences, and come from the top third of their class. Significantly, 50 of the 56 scholarship winners to date are in school or still working for Sheffield.

Sheffield's engineers, especially the new ones, are given much personal attention, receive challenging engineering assignments, are not kept on a job so long that it becomes dull routine, are promoted as fast as possible. Pay parallels the responsibility and rank of the job. These factors help explain the low turnover.

And the low turnover leads to fewer new engineers needed. Sheffield had to hire seven last June, and could choose from an original list of 60 applicants for the engineering jobs open in sales, research, designing and other departments. This meant the company could pick and choose. The men had been given standard tests by their university to establish their relative standings in math and certain engineering subjects. Then those surviving this screening were given aptitude tests by Sheffield management, and interviewed by at least four company executives, before final evaluation and selection.

Will the new engineer stay on with the company that has hired him? One executive said, "We keep more than 70% of the college graduates we hire."

At Warner & Swasey, men are carefully selected to fill specific openings. The man about to be hired is given a down-to-earth understanding of the company's planned program of salary increases. Starting pay is comparable to that offered by other good companies. No inducements are offered; fringe benefits are not exaggerated.

The graduating engineers are interviewed at their colleges by the personnel director and top engineering executives. About 40% of the interview time is spent telling the student about the company, 60% ferreting out his abilities. Scholastic records are weighed. The proportion of school expenses he earned is considered to be a measure, in some degree, of his ambition. For straight technical men, some weight is given also to extracurricular activities.

Likely-looking job candidates who express an interest are invited to visit the plant for two days. If married, they are invited to bring their wives along. During their visit, job candidates meet rank-and-file foremen, engineers, and practically all "top management" men. They are also given aptitude and mental tests, which are compared with tests of men who have succeeded. Each year, about 200 men will be interviewed on the campuses, some 80 will be invited to the plant, 50 or so will be offered jobs, and about 20 will accept.

WORKING WITH COLLEGES

An expansion program obviously spotlights the engineer-recruitment problem. The answer at National Cash Register, which has tripled the size of its design and research departments over the past seven years, is an attack along a broad front.

It conducts classes in cost accounting and shop practices. Like many other companies, it trains technical high-school graduates to become draftsmen and detailers. And it keeps in close touch with technical schools and colleges. It has a list of about 30 selected colleges called upon regularly in the search for new engineers. It does not overlook scholarships as a means to cement close relations with engineering colleges and prospective employees. In another approach used by NCR, professors from selected schools are hired as

CONTINUE TRAINING

"Selected engineers should be sent to schools to take refresher courses."

"The company subsidizes membership in engineering societies."

"Engineering magazines and books should be provided, and time for them allowed."

"Today, the engineering department must have first-class quarters."

"Give the chronic crabber little or nothing to criticize."

consultants. This company also sponsors research projects at universities.

In selecting college graduates, National Cash Register attaches major importance to college grades in math, physics and mechanics, but over-all scholarship need not be high. Personality is rated next in importance because teamwork is required to develop a new product. NCR has found that high scholastic marks do not always assure a high degree of engineering design ability. However, in the Research Div. there is a closer association between scholastic record and research ability.

Likely-looking graduating engineers tentatively accepted for NCR jobs are given a 2½-hr aptitude test at the nearest sales-branch office. Students who show a sufficient degree of alignment are interviewed by a number of department heads, and if qualified are allowed to make their own choice for a position.

WHY ENGINEERS QUIT

In many companies there has been a considerable change in the method of handling the new college grad when he joins the engineering department.

As explained by the vice-president of one of the companies covered in this survey: "Today, fewer college graduates care to go into strictly engineering design or manufacturing, as compared to only five years ago. Most engineering-school grads want sales; they feel engineering is too narrow. Sales offers more freedom, a better atmosphere in which to grow."

Is the emphasis placed on "broadened engineering education—more humanities" creating among engineering students an inferiority complex? Is the sales function being so glorified that the engineering newcomer decides he made a mistake—and quits?

At Reliance Electric, the new college graduate gets a complete, broad picture of company activities, personnel policies, business philosophy, and organizational structure. What is the result?

Of college grads coming to Reliance for interviews, 25% are hired. Of course, the men doing the interviewing, from the chief engineer down, have been trained in the art. Reliance values having the chief engineer and his assistants skilled in personnel management.

Result: Turnover in the engineering department, including sales engineering and research, is little more than 5%. Seventy to 80% of the college grads hired are still with the company five years later.

ORIENTATION HELPS

At Warner & Swasey, the college graduate is given an intensive week of company orientation; then follows six to ten months of training tailored to his background and objectives before he goes on engineering-design work.

"When he steps up to his first design or development assignment we want him to really know his business." A full-time counselor is available for advice or information. Department heads are called upon to give talks to groups of about 20. The company subsidizes membership in engineering societies.

It sponsors research projects at various colleges including Case, Ohio State and M. I. T. Where it can be arranged, W & S furnishes one of its engineers to work on a project and at the same time study for an advanced degree. He has good reason to be content: W & S pays his tuition and his full salary during the time he is studying. Similarly, this company subsidizes postgraduate night-school courses leading to MS.

At American Machine & Foundry, new grads are thrown right into design work—assigned to projects such as developing the design of cams or gear trains. They are not given any elementary work. Design and detailing are done by trained high-school or trade-school graduates, or men taken from the shop and trained. Of special interest and significance is the opportunity given to girls. For example, Miss Ruth Harlan of AMF heads up a design project that has a dozen or more engineers working on it.

Elementary drawing-board work at National Cash Register is done by high-school and trade-school graduates, or men from the shop who are beginning their engineer-training period. College-graduate beginners are assigned to a project such as the detail design-development of machine elements.

THE FLEDGLING AS CRITIC

When he begins his first job after graduation, a new-born engineer "puts his employer under a microscope." It is a peculiar kind of instrument that greatly

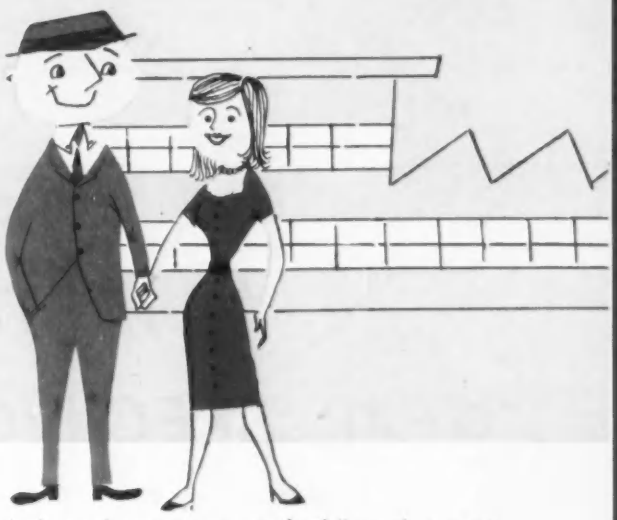
RECRUITING AND SCREENING

"About 40% of the interview is spent telling the student about the company; 60% ferreting out his abilities."

"Candidates . . are invited for a 2-day visit to the plant. If married . . to bring their wives."

"Prospects in the graduating class are interviewed by alumni on the engineering staff."

"Those surviving initial screening are given aptitude tests by management and interviewed by at least four company executives."



magnifies the company's shortcomings in the operation of its engineering department. Older employees who have a "real gripe" are more than willing to tell the newcomer all about it. The only way that management can contend with such situations is to make them impossible—give the "chronic crabber" little or nothing to criticize.

In the now-distant past, when engineering design was largely a matter of "making pictures" and the engineer was too often classified as a necessary evil, it was to be expected that engineers' salaries were low; the department was housed in a cellar, garret or other equally undesired place; and the authority of the chief engineer was on a par with that of a shop foreman.

That day is past. Today, the engineering department must have first-class quarters, with private offices for those doing responsible design supervision; the director of design is on a par with a vice-president; engineers are treated as professional men; and pay is on a fair salary scale throughout the department.

But salaries paid engineers remain a sore point to many new employes, particularly when the "going rate" for the new graduate is close to or even higher than being paid to men with the company for two, three, or even more years. Even worse, there is only a narrow margin between the beginner's salary and that of engineers who have been with the company 10 or 20 years. It does not take the newcomer long to discover this. Looking into the future, he visualizes himself working for the pittance being doled out to the veteran engineer. If he is any good, he quits.

HOW TO KEEP OLDER MEN

The usual company excuse for such a situation is: "We just can't afford to raise the old men to keep them in line with the higher salaries we must pay the new college graduate." Such remarks show that the problem has not been given enough thought. The company that keeps the whole range of engineers' salaries in line will have little trouble in hiring away the best talent of the company that doesn't.

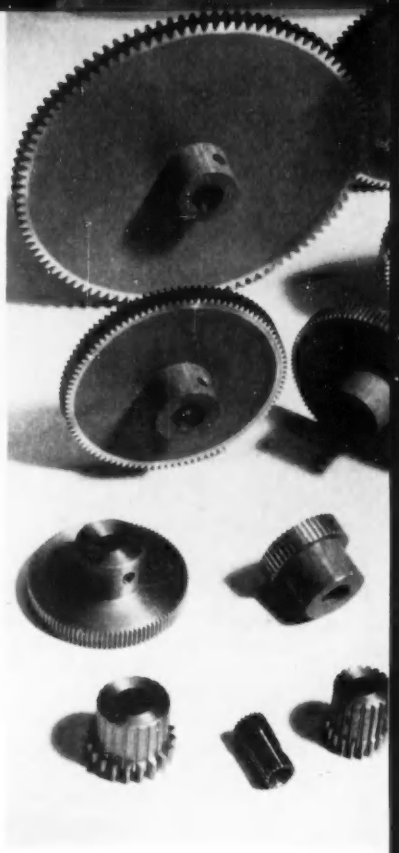
It has been said that the "old" engineers, 40 years plus, have lost value relatively because of the vast fund of new scientific and technological knowledge that has come into existence since they graduated. This again is a sad commentary on the failure of so many companies to "build" design engineers. They cast the whole of the burden on the colleges, then stunt the growth of the men whom they hire by not assisting them to keep abreast.

Every company of any size should provide for a continuing series of lectures, given within the company by qualified teachers, to keep engineers abreast of new developments. Selected engineers should be sent to schools to take refresher courses. Engineering magazines and books should be provided and time for them allowed. The cost is insignificant. And closer ties with educational institutions should be developed. Professional society fees should be subsidized.

In addition to an attractive salary scale and proper physical working conditions, other things can be done at little cost to make a job in the engineering-design department more attractive. It costs practically nothing to pay a little attention and give a little recognition to the design engineers—all of them. When it is reasonable and logical, they should be invited to attend a committee meeting, even though they may be there only as listeners. Above all, they should not be required to punch timecards. A clock-watching designer is a poor one.

Self-respect, pride and ego are more powerful motivating forces than the dollar. Too few managers of men have a wholesome appreciation of the fact until it is applied to them. It costs practically nothing to give an employee a feeling that he is respected.

William Russell, vice-president in charge of engineering at Landers, Frary & Clark, once said, "The prize money we give our designers for their ideas and inventions would be worth practically nothing to the company if we did not distribute the prizes at a company meeting. The president of the company hands out the awards given to the design engineers for their inventions. Wives, associates and friends of the award winners are in the audience. It is a gala affair. The presentation speeches give the recipients a lift of morale, confidence and a rightful ego that could not be obtained in any other way. And of course, the company sees to it that the increased value of these men to the design department, and therefore the company, is also reflected in the added pay."



7 Rules simplify INSTRUMENT GEAR SPECIFICATIONS

Specifying too many requirements is time-consuming and expensive. This article evaluates such considerations as backlash and tolerances, and boils specifications down to a minimum.

WILLIAM A. WIEGAND, *President, Dynamic Gear Co., Inc.*

Gears for light loads and moderate duty—often called instrument gears—cover a wide pitch range and are made in many precision grades. Selection can be simplified by following a few simple rules and keeping the specifications to a minimum.

1 Select the finest pitch that will carry the load. This permits reducing over-all size of the gear train. Stocked gears are available to 120 pitch, and can be made to order to 200 pitch.

2 For minimum backlash, pick gears with a 14½° pressure angle. The backlash here is considerably less than with 20° pressure-angle gears of equal precision (see chart). The 20° gears carry more load and have a longer life, load on most instruments is light and a long cyclic life is not required.

A 0.0015-in. tolerance on the pitch diameter, for example, will result in greater backlash (0.0005 in.) with 20° gears than with 14½° gears (0.00038). Viewed another way, a backlash range from 0 to 0.0013 in. for 14½° gears would require a max tolerance range of 0.0005 in. (for example, pitch dia might be 1.000 in. plus 0 minus 0.0005). But for 20° gears, the tolerance range is cut to 0.00038 in. This may increase cost of the gear by 40%.

3 Call for Precision I or Commercial IV class gears whenever possible, avoiding Precision II unless you are sure the tight tolerances are required. Over-designing gear trains is a common fault. Sometimes it is deliberately done to insure acceptability of prototypes—a later relaxation of tolerance is intended but, too often, never comes. Short target dates can also be responsible for needlessly tight tolerances; the designer assumes there will be insufficient time after receipt of gears for special fitting into the assembly. This makes both prototype and production models costlier than necessary. A Precision II gear can cost nearly 150% as much as its Commercial IV counterpart. For a typical gear in production quantities, here is how cost compares for the three classes of gears:

Commercial IV	$3
Precision I	3.54
Precision II	4.45

4 Specify bore tolerance, face run-out, and pitch-dia tolerance in line with AGMA requirements for the class. Gear drawings often call for over-loose tolerances on these dimensions, especially when the specifications include a drawing of the gear blank. A gear cannot be made more accurate than the gear blank on which it is cut.

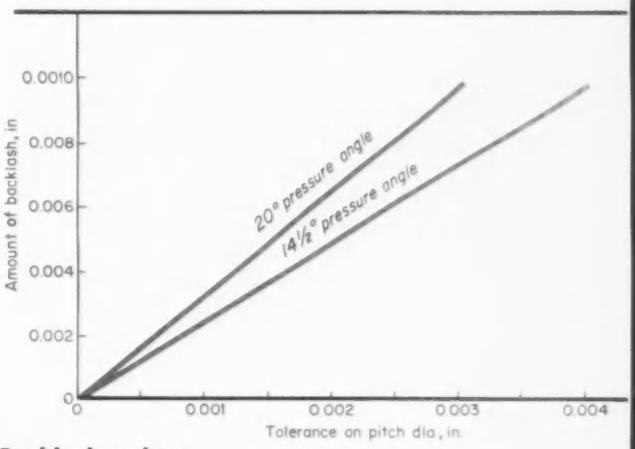
Typical is the error of calling for a 0.001-in. tolerance on the bore for Precision I or II gears.

5 Obtain the max tolerance on OD by using the AGMA formula, 0.2/pitch. This gives max allowable variation below nominal OD. Applying the formula to a 48-pitch gear, for example, indicates acceptability of an OD tolerance that is 0.004 in. under nominal.

Of value also is the common practice of applying

AGMA Gear Tolerances

Type of Tolerance	Gear Class		
	Commercial IV	Precision I	Precision II
Tooth-to-tooth error	0.0007	0.0004	0.0003
Tooth composite error	0.0015	0.0010	0.0005
Plus tolerance on bore dia	0.0008	0.0005	0.0003
Lateral (face) runout per in. of dia	0.0020	0.0015	0.0010
Minus tolerance on PD	0.0020	0.0010	0.0005
Concentricity of OD to bore	0.0015	0.0010	0.0005



Backlash values . . .

for instrument gears with 14½° pressure angle are considerably less than those for 20° gears.

double the pitch dia tolerance to the OD. On a Precision I gear with −0.001-in. tolerance on the PD, a −0.002 in.-tolerance would be allowed on the OD; on Precision II with −0.0005 PD, the OD tolerance would be −0.001 in. For normal applications, however, such tolerances may be tighter than necessary, and it is better to apply a tolerance of −0.002 in., or the formula −0.2/P, whichever is the lesser figure. Where a gear is not top-hobbed, these tolerances should certainly be adequate.

6 Specify top-hobbing whenever concentricity of the OD to the PD is important. In this operation, PD and OD are generated simultaneously and the whole depth of tooth is governed by the hob or cutter. It is possible to hob a gear to PD size and find the OD slightly oversize because of slight errors in manufacturing or sharpening the hob.

If this occurs split the tolerance to permit a plus tolerance—that is, specify +0.001 in. or +0.1/P, whichever is the lesser (rather than specifying the −0.002 in. or −0.2/P).

Two methods for specifying pitch dia of instrument gears, and its tolerances, are the center-to-center distance specifications, and measurements over pins. In the center-distance specifications, tolerance is not applied directly to the PD, but to the variations in center distance as the gear is rolled in mesh with a hardened and ground master gear.

Because AGMA specifications tie down the permissible center-distance variations and backlash for the classes of gears, pitch dia should be specified on the drawing as being for reference only. For example, by specifying a Precision I, Class C, 48-pitch gear, the total permissible variation in center distance is 0.001 in., and the backlash is 0.001 to 0.002 in. These figures can be obtained from the AGMA Standard 236.04 for fine-pitch gears, or from "Methods for Specifying Precision of Spur Gears," Nov. '56, p. 135.

7 Keep drawing specifications of the gear teeth to a minimum. Unless gears are to be critically inspected, only the information in the required-data column of the simplified form (right) need be specified.

TOO MANY SPECIFICATIONS?

Only the gear-tooth information in the required-data column below need be specified. The optional data, usually included for inspection purposes only, are derived: (6) and (7) from standard gear formulas; (8) and (9) from reference tables; (10) through (16) from the AGMA specifications in (5).

	Required Data	
1.	Number of teeth	48
2.	Diametral pitch	48
3.	Pressure angle	14½°
4.	Pitch dia (ref.)	1.000
5.	AGMA spec	Precision I, Class C
	Optional Data	
6.	Addendum	.0208
7.	Whole depth of tooth	.0478
8.	Measurement over wires	1.0208
9.	Wire dia	.0360
10.	Center-to-center distance	1.125 +.0005 −.0010 (with 1.5 in. master gear)
11.	Testing pressure	22 oz.
12.	Tooth-to-tooth error	.0005
13.	Total composite error	.0010
14.	Plus tolerance on bore dia	.0005
15.	Lateral runout per in. of dia	.0015
16.	Concentricity of OD to bore	.0010

EDITOR'S NOTE: A simple method to check pitch dia is to place two pins between opposite teeth and measure the distance with a micrometer. Tolerances for the measurements have recently been computed in "Tolerances for Overpin Measurements," May '57, p 194.

Guest Editors Sift London Conference

There is a wide gap between theory and fact in the phenomena of friction and wear. But this gap was narrowed in several areas by papers presented at the London Conference on Lubrication and Wear, sponsored last month by Institution of Mechanical Engineers.

Of the 104 papers presented, quite a number were of primary interest at the design level. To evaluate them, *Product Engineering* commissioned two well-known American specialists to prepare the discussions that follow. Ernest Rabinowicz selected the papers on friction and wear for comment; H. A. Hartung took over the papers on lubrication.

Papers are identified by the numbers assigned to them in the official program of the conference. Copies may be secured from Institution of Mechanical Engineers, 1 Birdcage Walk, London, SW 1. Single copies are one shilling; complete set, two pounds.

Friction and Wear

ERNEST RABINOWICZ, *Lubrication Laboratory, Massachusetts Institute of Technology*

SOLID FILM LUBRICANTS— BEST REPRESENTED GROUP

A review paper by Bisson, Johnson and Swikert of the N.A.C.A. (31) discusses their work with oxides of iron as lubricants for steel, and the value of layer lattice lubricants like MoS_2, graphite, cadmium chloride, and the effects of solid binders and of contaminants like silica. Campbell (61) of the M.E.R.L. lab in Scotland points out that E.P. lubricants generally contain both lead soaps and sulfur compounds, and that lead sulfide can thus be formed. He finds that PbS is indeed a solid film lubricant. Mitchell and Fulford (27) experiment with combinations of MoS_2 and binders. For steel surfaces, they find Teflon, syrup and resorcinol-based resin to be the best binders, in that order. Deacon and Goodman (17) of Cambridge U. form combinations of graphite and Mos_2 films by rubbing on dry, by dipping a metal in a colloidal suspension, and by sliding surfaces together in the presence of the suspension. Rubbing dry is successful, suspending is useless, sliding in the suspension is dubious.

A remarkable phenomenon is noted by Opitz (53) of Germany in a paper on the wear of cutting tools. He finds that if the current flowing through the machine tool (produced by thermal emf at the cutting zone) is opposed by an external voltage, the wear changes drop as much as 2½ times.

Campbell (56) of the M.E.R.L. lab discusses the sliding of stainless steel surfaces in the presence of liquid sodium, and finds that circumferential grooves are more helpful than random ones. Freitag (44) of Cambridge U. summarizes his recent work with the rotating ball method of observing friction phenomena at high speeds (to mach 3) and notes that the drop in frictoin at high speeds cannot be caused by bulk melting since the available energy is too low. Simpson & Russel (85) of Napier & Sons, England, find that strong magnetic fields and quite moderate electric currents lead to the rapid deterioration of ball bearings.

COMBINING MATERIALS TO IMPROVE QUALITIES

Papers by Mitchell (74) and by Mitchell and Pratt (101) on friction and wear of Teflon and of mixtures of Teflon and other materials seem to foreshadow a future trend, that of making sliding systems composite to combine advantages of both materials.

Duckworth and Forrester (90) present a new theory of wear based on dimensional analysis. The final expression in their equation contains as variables the melting temperature of the metal, its specific heat, the hardness, the atomic diameter and the free energy of oxide formation. The properties of the lubricant do not appear explicitly in the theory.

RUSSIAN CONTRIBUTIONS

The six Russian papers make realistic assumptions to get right down to the basic problem. This is even more surprising when it is noted that most of the Russian work in this field is done largely by physicists—in contrast with English work by chemists and metallurgists, and American work by mechanical engineers.

Two of the six Russian papers are purely experimental. The paper by Khruschov (46), on the resistance of metals to abrasive wear, shows that the amount of wear is inversely proportional to the intrinsic hardness, but that work-hardening does not count because the asperities are in any case fully hardened. Lazarev and Derjagiun (11) develop an unusual friction measuring device, a wire tribometer, which may open new avenues in basic research on friction. Kragelsky and Sabelnikov (7) derive a new law on the relationship between the friction force and normal pressure, and confirm the law experimentally. The relationship is

$$f = A + BW^{-1/3}$$

where f is the friction force per unit of contact area, W is the pressure at the area, and A and B are material constants.

Russian authors cite work done in other countries more frequently than we do, as an analysis of the papers at the conference makes plain.

Origin of Papers Presented	Country of reference cited			
in London	US	UK	USSR	Other
US	55	41	0	4
UK	42	42	2	14
USSR	13	19	56	12

US and UK authors cite each other almost as much as they cite themselves, but neither cite Russian papers as much as the Russians cite work published in English. In fact, no Russian work was cited by US papers presented at the conference. Language barrier?

New Concepts on Lubrication

H. A. HARTUNG, *Lubrication Engineer, The Atlantic Refining Co., Philadelphia*

With present analyses of thrust-bearing performance, the load that can be carried under known conditions depends on the thickness of the oil film. Neal (42) points out that this is an incomplete assessment, and that the friction and film thickness must be considered as functions of load, velocity and viscosity. This limits the range of stable operations of stepped thrust bearings. For film thicknesses below a certain value (which depends on the step height and position) friction increases while load-carrying capacity remains substantially constant.

METAL FOIL BEARINGS

A metal-foil bearing of the type suggested by Blok and van Rossum was constructed and operated by Patel and Cameron (73). Measurements indicated that most of the temperature rise occurred in the first 30° of the wedge. The data are limited in scope, but the first to appear on this interesting development in the bearing field. The authors are modifying the apparatus so that higher loads (over 60 psi) can be accommodated.

Wettability of a lubricant on friction in a journal bearing was improved by coating the bearing elements so that the oil used had a high contact angle, reported Campbell, Pilarszyk and Papp (30). For this they used a perfluorodecanoic acid. Comparing the friction before and after treatment with this reagent, friction was higher when the lubricant wet the surfaces better. All experiments were run at low loads and rather high Sommerfeld numbers (0.6 or greater).

Oil films were successfully photographed in journal bearings under dynamic loading conditions by Cole and Hughes (87). They used glass bearings and ultraviolet illumination. Cavitation occurs in the unloaded regions just as with unidirectional loading. When the rotating load speed is half that of the journal speed, the oil film exists only over a very small angle. With an oscillating journal ($37\frac{1}{2}°$) at speeds up to 750 cycles/min, there was indication of failure to form a hydrodynamic film.

Computer solutions to the problem of elastic surface deformation in hydrodynamic slider bearing lubrication were obtained by Osterle and Saibel (35). When bearing deformation alone is taken into account, the calculated load-carrying capacity is slightly less than when the bearing is assumed to be rigid. However, slider deflections can more than compensate for this loss, so that a thin, flexible rider running against a flexible bearing may result in a higher capacity than a rigid bearing and rider.

In discussing the lubrication of porous metal bearings, Morgan (88) (89) points out that oil actually circulates in such a bearing. In general, these bearings run at high eccentricity ratios, with somewhat higher coefficients of friction than similar solid bearings. The author has developed a modified Reynolds equation for this system. An approximate solution is provided, based on narrow bearing theory.

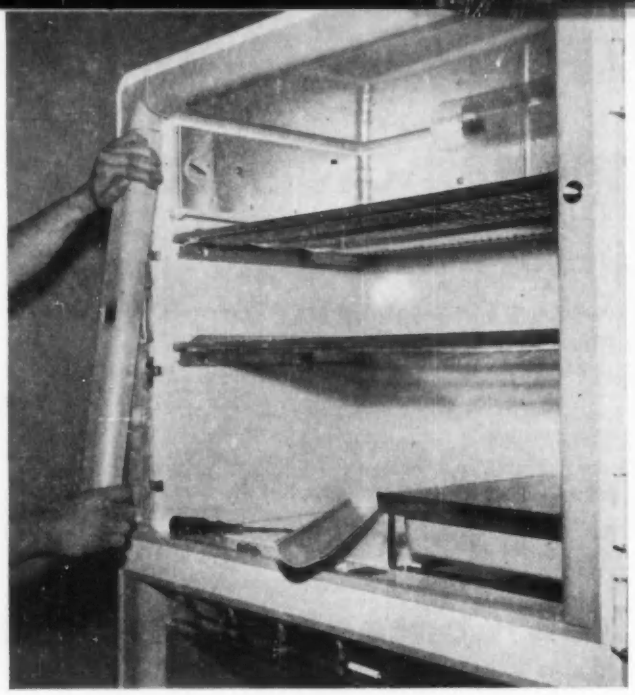
LUBRICATING WITH GAS

Analysis of gas-lubricated bearings has been extended by Ausman (22) to include end-flow factors for journal bearings of finite width. These factors can be used with the solution of Katto and Soda to obtain the load-carrying capacity of finite journal bearings. The author finds better agreement for air, neon and hydrogen when the gas is assumed to behave adiabatically. (See special report in this issue on gas-lubricated bearings, page 99.)

Using glass bearings and steel journals, Cole and Kerr (95) studied the operation of self-acting (hydrodynamic) air bearings. They found, with good alignment, load capacities as high as 1 psi per 1000 rpm journal speed. With eccentricity ratios below 0.2, half-speed whirl of the bearing was encountered with loads below 4 psi. Temperature rise in the bearing was small, and behavior of the air seems to be isothermal.

Extensive tests on the wear of connecting rod bearings by Baker and Braily (102), show that failure is usually caused by particles embedded in the bearing. High rates of journal wear are promoted by high stroke-to-bore ratio, by low crankshaft rigidity and by high bearing width-to-bore diameter ratio. Low lubricant viscosity, high engine temperature and high engine speed also contribute to rapid journal wear.

Parts made from plastic extrusions, like the refrigerator molding being installed at right, are helping keep costs down on many new designs . . . a good reason to review



Plastic Extrusions

ROBERT MARX, *Development Engineer*
Anchor Plastics Co., Inc.

Mushrooming postwar growth of products containing substantial quantities of plastic parts is evidence of engineering and consumer acceptance of plastic materials. In the 10-year period 1946-1956, for example, combined sales of refrigerators and washing machines doubled, of automobiles tripled. Television and unit air conditioning are two industries which cut their teeth on the postwar hunger for luxury items–and both found plastics more than palatable.

Plastics as engineering materials have one outstanding virtue often taken for granted: They can be easily formed into complex shapes by many strikingly different processes . . . extrusion, injection or compression molding, casting, and vacuum forming, for example. The value of extruded shapes in product design is frequently obscured, however, by the common notion that dies are expensive, and extrusions should therefore be considered a last resort.

But plastic extrusion dies are inexpensive, running from only $45 to seldom over $200. Further, these figures include all other tools necessary to produce the extrusion to proper shape tolerances in unwarped lengths. Once made, plastic extrusion dies are easily altered even after production runs have been started, which means assembly bugs involving produced parts are often solved quickly. For influence of extrusion size and shape on die charges, see table, opposite page.

DESIGN OF PARTS

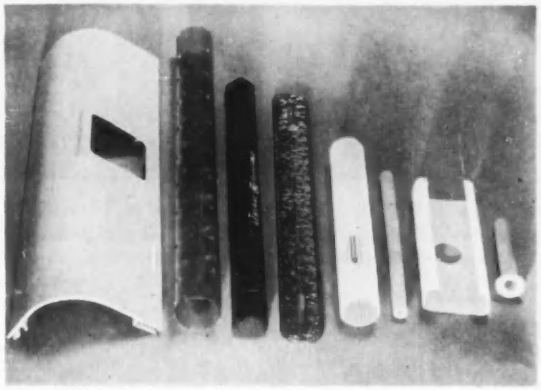
A significant trend in the field is increasing demand for fabricated components–basically, these are straight extrusions, but with one or more secondary operations that convert the extrusion to a finished part. Fabrication often outweighs extrusion costs. Increasingly, extruders are setting up secondary fabricating shops to tap this market for finished parts.

In designing sections for extruding, tolerances must be wider than for metal working, because of greater thermal expansion. Extruded shapes, semiliquid when they leave the die, shrink as they cool; and shrinkage is uneven for different parts of the cross-section because varying thicknesses cool at different rates.

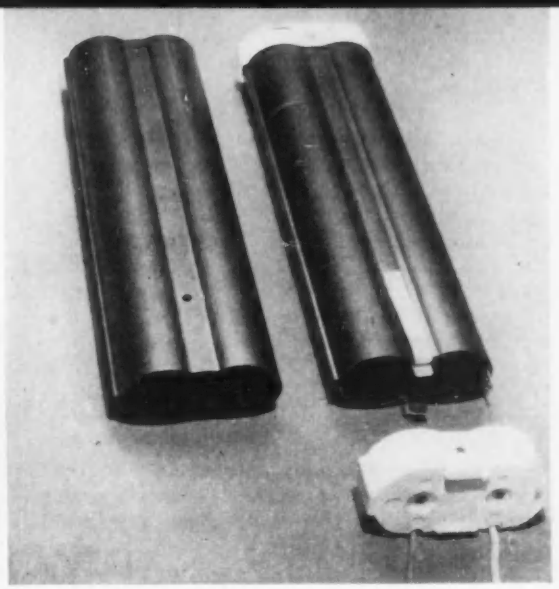
Fortunately, shrinkage can be anticipated by the designer prior to manufacture, and controlled by the extruder during production. Tolerance of $\pm 1\%$ can be held on most cross-sections, and is a good figure for preliminary design. Other general rules:

- Thin, uniform thicknesses are best because cooling is rapid and even, minimizing warpage caused by differential shrinkage.
- If such thicknesses are impractical, keep the ratio of thick-to-thin as low as possible, to minimize differential shrinkage.
- Specify tolerances only on dimensions that require them. Too-many tolerances are often more trouble than too-close tolerances.
- Design the section for symmetry about one or more axes. This simplifies shrinkage control during manufacture, allows closer tolerances.
- Holes not symmetrical with the cross-section are difficult to keep oriented properly, in shape and tolerance. Even a hex hole in a hex shape may tend to rotate

Significant Trend: Extruders Add Fabrication Steps That Turn Out Components Like These . . .



Fabricated extrusions cut costs . . .
From left: high-impact styrene refrigerator molding with draw-formed latch boss; acetate insecticide-container with punched holes; ethyl cellulose antenna housing forms corner of radio, carries manufacturer's name; polyethylene case handle



has punched slots for flattening when not in use; polyethylene filler tube for railroad battery has slots to admit activating water, and external flutes for escaping vapors; polyethylene extension shaft for TV set has external flutes for easier hand turning; nylon swivel plate for rear window on hardtop auto slows wear and prevents rattle; polyethylene extension shaft has swaged end for positive fit. At right: **Battery case**, above, for Admiral portable radio is basically an extrusion with injection-molded end caps. Note indexing projection on extrusion and end cap for correct positioning.

out of position. Holes within extruded shapes require special consideration.

• Work closely with an extruder on any proposed design before production quantities are ordered. Plastic extrusion requires considerable finesse, both in die manufacture and production technique.

MATERIALS

Most shapes can be extruded from any of the commonly used plastics; consequently the designer can select the best material on the basis of environmental and operating conditions. Adjustments in die profile, flow contours within the die, extruding conditions, tension on the extrudate, and special fixtures will permit extrusion of a properly designed shape from the more difficult materials.

Low-shrinkage materials (cellulosics and styrenes) are easiest to extrude; those with higher shrinkage (polyethylenes for example) are more difficult. Plastics with sharp melting points, like the polyamides, also give shrinkage trouble.

A simple T-shape extrusion shows problems caused by shrinkage: Material at junction of top and leg tends to cool more slowly than the rest of the section, causing differential shrinkage. Unless the material flow to this area in the die is carefully controlled, a slight bump or sink mark will occur on the flat—usually noticeable only in oblique light. This can be corrected during

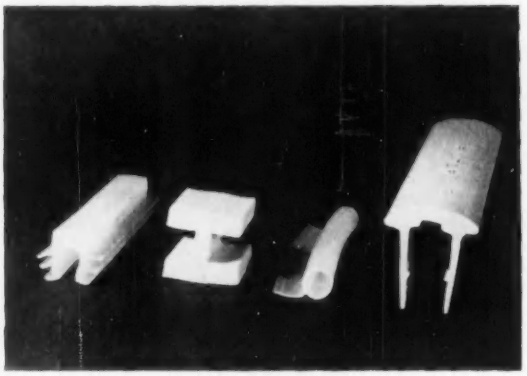
Extrusion Die Costs Compared

Shape / Use	Lens strip	Edging	Panel joint	Breaker strip	Door track
Relative Cost	1.0	1.5	2.8	3.1	5.3

extrusion, or by designing a fluted or beaded extruded surface pattern that will disguise the sink marks. On any flat extrusion surface over 1 in. wide, an extruded pattern is recommended rather than a plain surface.

Plastic extrusions are colored easily, but where the extruded part is matched to an adjacent injection-molded part, a slight difference may show even when the same material is used. This is because the surface reflectivity of parts produced in a closed mold is different from that obtained by the extrusion process—a difference negligible with glossy materials, but more pronounced with rougher-finish materials like high-impact polystyrenes.

All plastic extrusions fit into one of five basic form groups and are priced accordingly: rods and strips, round and oval tubes, cored extrusions, complex solid shapes, and complex hollow shapes. Cored shapes contain metal or wood inserts and are extruded much like coated wire.



Thin, uniform thicknesses . . .
are best (far right). Abrupt transition of thick to thin (3 pieces, left) causes differential shrinkage and results in warpage.

FABRICATION OF EXTRUSIONS

Many parts are simplified if a plain extrusion is used as the basic frame, then fabricated further to make the finished article. Sometimes the finished component has little resemblance to the original cross-section, and does not easily show that it was made by extrusion. Here are the basic fabricating procedures:

Cutting is the most important operation. Methods employed are: chopping, saw-cutting, and automatic blade-cutting. Chopping works for most small and medium-sized sections where high accuracy is not needed. Saw-cutting is the only process suitable for accurately cutting brittle materials and large cross-sections; is also used for precision cutting of soft materials in all but the smallest diameters. Automatic cutting as the shape is extruded is economical for large-volume precision cutting on small shapes. It can cut cost of small extruded parts 30 to 75%.

Normal tolerances for all cut extruded components are $\pm\frac{1}{64}$ in. for lengths up to 4 in.; $\pm\frac{1}{32}$ in. from 4 up to 36 in.; $\pm\frac{1}{16}$ in. from 36 to 72 in. For precision-cut short lengths, usually small-dia tubes, closer tolerance cutting can be specified. For example, a $\frac{1}{8}$-in. dia tube

PLASTICS FOR EXTRUSION

Cellulose acetate is an economical general purpose material extrudable in thin thicknesses. It is odorless, tasteless, easily cleaned. Two problems with acetate extrusions: comparatively high water absorption can warp complex shapes; it is not recommended for outdoor applications.

Cellulose acetate butyrate is similar to acetate, but has greater resistance to distortion under heat and moisture. It has greater dimensional stability after extrusion because low water absorption minimizes warping. CAB is generally preferred over cellulose acetate for moldings and complex shapes, and is suitable for outdoor use.

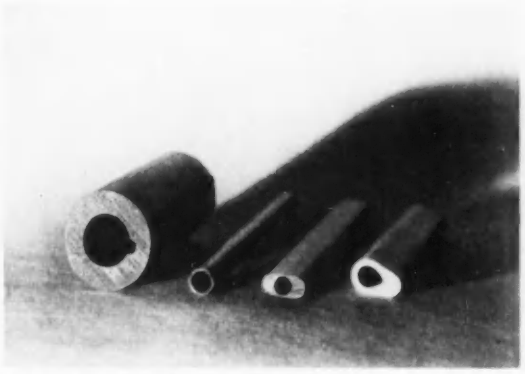
Ethyl cellulose, toughest and lightest of all cellulosics, has excellent dimensional stability over a wide range of temperature and humidity. Impact strength is high, and retained at service temperatures below zero. Ethyl cellulose is best of the cellulosics for electrical insulating applications where the extrusion may have to take much mechanical abuse.

Polyethylene tubes and shapes are readily extruded and useful in dielectric applications where chemical inertness is required, and where flexibility and economy are important. Stress cracking may be a problem; but a special resistant grade is available. Polyethylenes are now grouped: low, and high density. With greater tensile strength, rigidity and heat resistance to 250 F, the high-density grade permits extrusions where low-density polyethylenes cannot be used. Electrical and chemical properties of both grades are about the same.

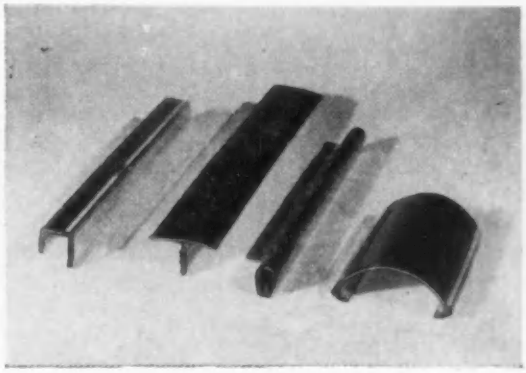
Polystyrene, one of the oldest extrusion plastics, is a low-cost crystal-clear material with negligible cold flow and low specific gravity. Electrical properties are comparable to polyethylene. Principal disadvantages are brittleness, poor resistance to weather, and crazing. Development of styrene-acryonitrile copolymers about 10 years ago improved performance in these areas, but a major improvement came from blending with acrylonitrile rubbers. High-impact styrenes are made with a wide range of mechanical properties varying with the ratio of resin to rubber. These are the most economical rigid thermoplastics available for extrusion.

Acrylic resins are the most durable extrusion material. This—together with unusual clarity, high surface gloss, scuff-resistance, and light piping qualities—make them widely applicable in decorative and outdoor designs. Acrylics are not as easily extruded as high-impact styrenes, but complex shapes are possible and tooling costs about the same. Smooth die surfaces are necessary to give mark-free surfaces because acrylics tend to wet the die and reproduce the most minute imperfections.

Polyamide resins (nylons) are tough, light, strong plastics with low coefficient of friction, excellent abrasion and corrosion-resistance—but difficult to extrude. However, special new grades permit extruding simple sections with thin walls. Control of shape tolerances and surface irregularities in the extruded shape is not as close as with other extruded thermoplastics. Nylon can be colored, but in most cases is used in its natural state—a yellowish white.



Holes tend to lose shape . . .
unless enclosing walls have reasonably uniform thickness, but precise hole shape may not be necessary as in handle at right



Coring with metal foil . . .
gives lustrous trim with protective plastic finish for appliances, carrying cases and furniture.

can be cut within ±0.010 in. for a 4-ft length. Saw-cutting is not used for extremely soft materials because the wheel tends to fill and tear the extrusion.

Punching and die-cutting are performed most easily on the following: cellulosics, polyethylenes, nylon, and high-impact polystyrenes. General-purpose polystyrene and acrylics are not readily cut this way. Dies are the same as for metal, but no lubrication is required—giving clean parts without secondary degreasing operations. Cut edges of stamped extruded parts are not sharp and edge finishing is not usually required, further reducing unit costs. Cut or sawed edges will have the same color as the extruded surfaces because coloring agents are uniformly dispersed. This also eliminates an additional finishing operation.

Post-forming of extruded sections—flaring, swaging, bending and drawing—is done by reheating extruded sections and forming them to desired shape in special dies, molds and fixtures. Cost of such fixtures is usually minor compared to costs of injection-molding dies for similar items. Forming operations are economical for items where production quantities do not exceed 30,000 on the average. A typical formed part is the draw-formed latch mounting area in the refrigerator molding shown on page 85.

Multiple drilling of mounting holes, plain or countersunk, is economical. Narrow borders between the holes and edge of the extrusion, however, will result in tear-out, and tolerances for drilled holes cannot be held as closely as on metal parts.

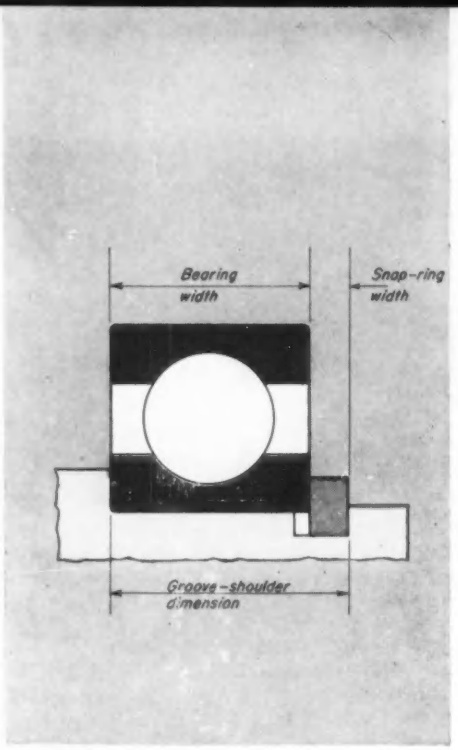
Decorating processes most frequently used are: hot-stamping, silk-screening, offset-printing, and spraying, in that order. By printing and spraying the rear or underside of a transparent extrusion, scratching or wearing of the lettering and decorative material is eliminated. Extruded moldings cannot be produced with the same uniform surface as calendered sheets or cast plates, so large areas with complex designs or detailed printing should be avoided. Surfaces on narrow flat extrusions, and most tubular shapes, are excellent and can be easily decorated by the four basic processes.

Assembly operations fall into two subgroups: extruded plastic parts attached to other larger components; small parts attached to extrusions, the extrusion serving as load-bearing body. For both groups ordinary screws (flathead, countersunk, half-round) can be used. For thin walls, extra widehead screws, rivets, or preferably washers, are needed to prevent tear-out. Automatic torque tools, if used, take lower pressures to avoid fracture or distorting.

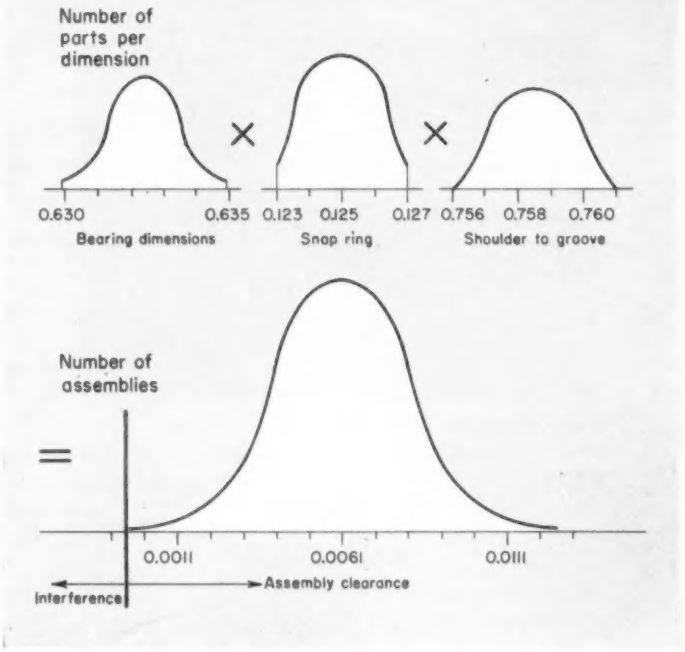
Where the extrusion is the body, self-tapping screws require a thread engagement at least as great as the screw dia, with thread forms specially designed for fastening plastics. When heavy parts are attached to thermoplastic sections, cold-flow deformation may occur, so the extrusion must be supported or stiffened in this area.

Cementing is an alternate method of fastening, and all the extrudable plastics, except the polyethylenes and fluorinated compounds, are assembled simply this way. These two are inert and require special adhesive procedures for sound bonds. Polyethylene can be heat-sealed to itself.

EDITOR'S NOTE: Some alternative methods for designing plastic parts are covered in these recent articles:
"How to Design Cost Out of Plastic Parts," Oct 14, '57, p 77, points out costly requirements, such as heavy wall sections and extra-close tolerances, that aren't always necessary. Charts classify materials and processes for ready reference.
"Epoxy Castings," June '57, p 135, discusses a lower cost alternative to metal or molded plastics for limited quantities of complex parts.
"Tough, Rigid Thermoplastics," Nov '56, p 167, simplifies selection of plastics for high-impact applications. Chart covers mechanical, electrical and optical properties for 28 compositions.
"Vinyl Laminate," July '56, p 167, shows how steel can be precoated with plastic sheet for formed parts requiring wear-resistant and colorful finishes.
"Plastics for Structural Uses," June '56, p 167. This staff report summarizes new developments in materials, processing techniques, and methods of reinforcement that make plastics suitable for many load-carrying applications that were previously impractical.



1 Assembly tolerances . . .
can be predicted by probability for such applications as this bearing mounting.



2 Taller and narrower . . .
than the three normal distribution curves for parts at top, the assembly curve is obtained by multiplying their tolerances.

PROBABILITY APPLIED TO

GEORGE D. PHEIL
Racine, Wisconsin

Production runs of assemblies call for statistical analysis of part tolerances. But with shorter runs, mathematical probability provides a simpler method that's just as positive.

Statistical analysis of assembly tolerance is based on an infinite number of parts or, at least, on a reasonably large production run. The familiar bell-shaped distribution curve may center on the tolerance band or it may shift toward one extreme or the other depending on the production method.

When three parts are assembled, such as ball bearing, snap ring and shouldered shaft in the illustration above, the normal distribution curves of each part are multiplied to determine how the assembly tolerance will be distributed. This results in a tall, narrow curve of assembly fits. But for shorter runs and job-shop production, the assumption of statistical distribution is inapplicable. It is far more logical to assume that individual parts have equal probability of being anywhere within their tolerance band. And the distribution of assembly fits becomes a fairly broad bell-shaped curve.

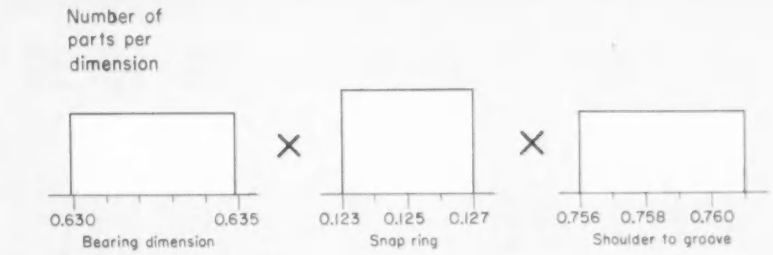
PROBABILITY APPLICATIONS

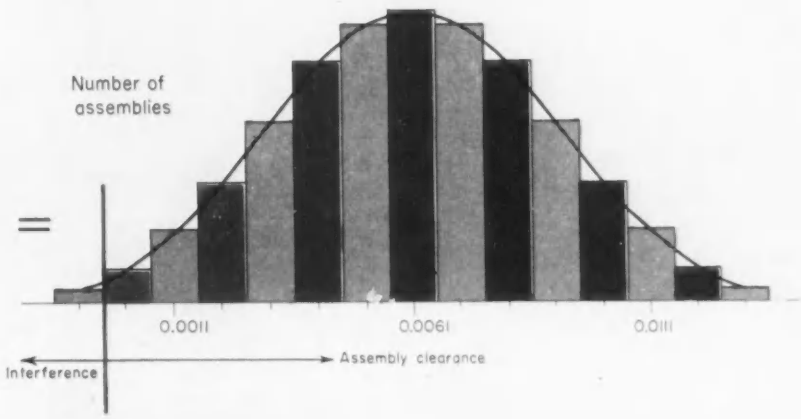
To assure that all assemblies are clearance fits, the shaft-shoulder dimension may be made larger than the maximum sum of snap ring and bearing. For example, assume a ball bearing whose width is 0.6299 in. (+ 0.000 to − 0.005) and a snap ring 0.125 in. (+ 0.002 to − 0.002. The shoulder-to-groove dimension would be set at

Max bearing width	0.6299
Max snap-ring width	0.1270
Positive clearance	0.0010
	0.7579

or, say 0.758 min with 0.003 tolerance for a 0.761 in. max. Clearance would vary between a min of 0.0011 and max of 0.0131 in.

This method works positively, but almost the same insurance can be had by assuming that 10% of the full tolerance range will never actually occur even though mathematically feasible. The method subtracts 10% of the sum of tolerances of all three parts from the stack height of ring and bearing, and uses the resulting dimension as min shaft length. For example:





3 Probability curve . . . is product of three equal-chance distributions, and is considerably broader than usual distribution curves. Of total variation, 1 unit in 180 (cut-off area) will 10% can be neglected safely; only result in interference fit.

ASSEMBLY FITS

Bearing width (+ 0.000 to − 0.005)	= 0.005
Snap-ring width (+ 0.002 to − 0.002)	= 0.004
Groove location 0.005	= 0.005
	0.014
10%	= 0.0014
Max bearing width	= 0.6299
Max snap-ring width	= 0.1270
	0.7569
	− 0.0014
Min groove limit	= 0.7555
	or 0.756 in.

Groove dimension = 0.756 (+ 0.005 to − 0.000)

Note that the 0.005 tolerance gives the shop a good workable tolerance as compared to 0.003 in the former method.

If bearing and snap ring go to their max dimensions the stack is 0.7569 to fit into a 0.7560-min groove dimension, resulting in an interference fit of 0.0009 in. If bearing and snap ring are at their min widths and the groove dimension is max, the clearance is 0.131 in. Note that the max limit on the groove dimension is the same for both methods.

HOW MUCH CHOICE?

If the snap-ring groove can be machined to 6 different dimensions at 0.001-in. increments within the tolerance specified; and if the bearing can be selected in just 6 different widths at 0.001 in. increments; and the snap ring can be selected in just 5 different widths at 0.001-in. increments; then these three choices can be made in just $6 \times 6 \times 5$ ways. The number of ways should always be understood as the number of different combinations possible.

Of the 180 possible combinations so formed, only one sets up interference. The next smallest combination will still have 0.0001-in. clearance. An alternate draw, at random, of another bearing or snap ring will break up the interference combination. Thus the 10% of tolerance reduction in shoulder dimension increases risk by a tiny amount but permits broadening the shaft tolerance to 0.005 in.

In an assembly that also includes such parts as spacers, retainers and oil slingers to be located by a snap groove, the 10% factor is even more important because stack height will vary still more.

EDITOR'S NOTE: Other recent articles on assembly tolerances and the use of snap rings:

"How to Design with Shims," Aug 57, p 164; how relation between thickness, clearance and tolerance determines size.

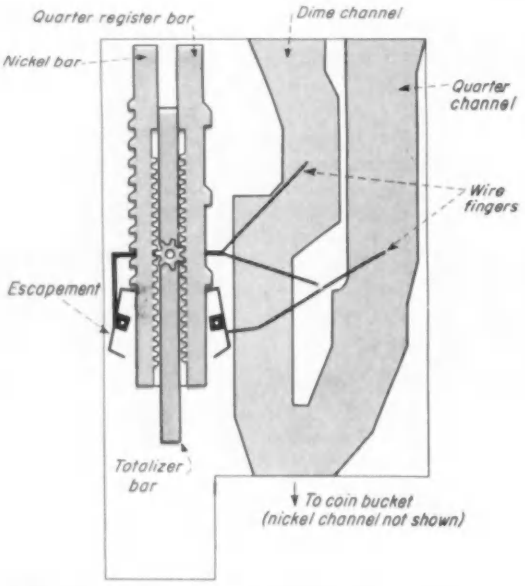
"Vectors Simplify Tolerance Analysis," July '57, p 195; a graphical method for pile-up of tolerances when dimensions are nonparallel and nonrectangular.

"Machining Tolerances," May '57, p 219; practical tolerances for various machining operations.

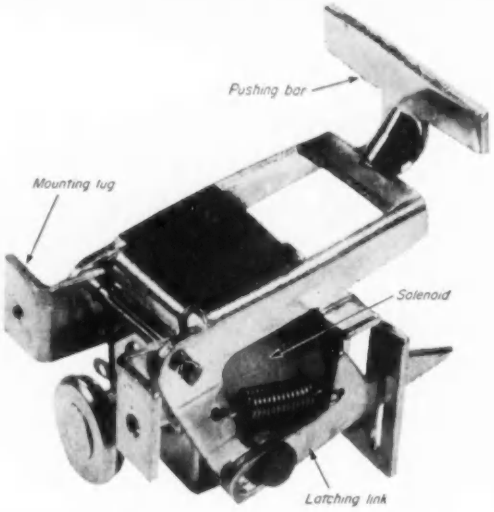
"Grooves for Retaining Ring Assemblies," Jan '57, p 158; function of the groove; its relation to the retained part; how to cut grooves properly; the effects of improper grooving.

Machine Sells at Four Prices

Twenty brands of cigarettes are sold at four prices by this vending machine that accepts nickels, dimes and quarters in any combination. Prices may be preset from 5¢ to 50¢ per pack. Made by the Rowe Manufacturing Co., Whippany, N. J., it holds up to 700 packs of any size.

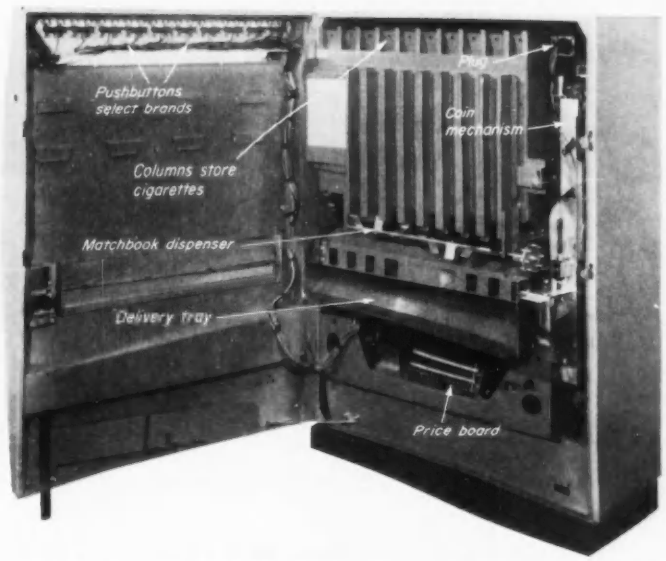


Falling coins operate escapements . . . that position totalizing bar. They strike wire fingers that rock escapement pawls and cause register bars to drop the distance between teeth. Nickel bar has five times as many teeth as the quarter bar; dimes strike two fingers sequentially and actuate nickel bar twice. A gear on the totalizer bar engages racks on both register bars and, when a register bar drops, rolls on the opposite bar to move totalizer an equal distance. This positions a rotary contact, closing an electrical circuit corresponding to sum of the coins deposited. If amount is incorrect, vending cycle does not start and customer must operate coin-return.



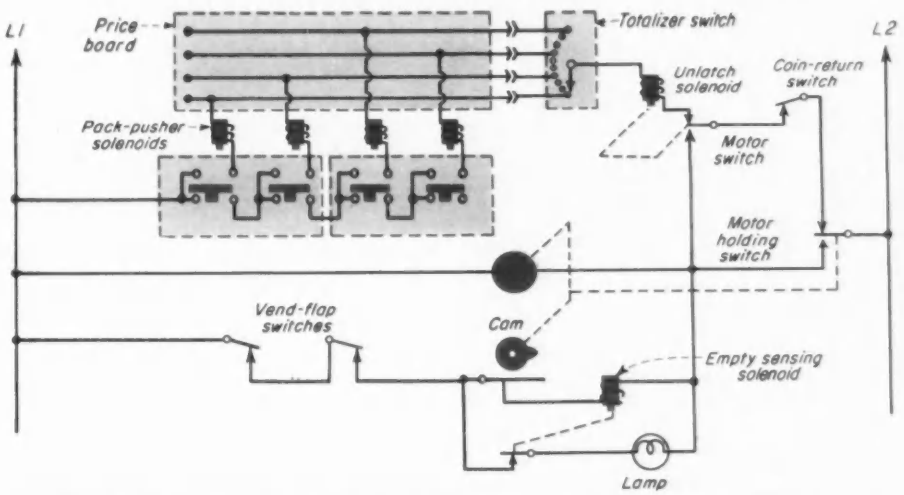
Pack pushers are self-latching . . . and do not require critical alignment with storage columns at assembly. They are mounted on the front and rear delivery carriages and move forward under the cigarette columns during the vending cycle. The particular pack-pusher energized by the brand-selection circuit is latched in the raised position as shown in illustration. When this pusher moves forward, the pushing bar rides above the side shelves supporting the stacks of cigarette packs and ejects the lowest pack. Then, a cam unlatches the pushing bar, allowing it to pass under the columns on the return stroke. Latching link is nylon and requires no lubrication.

IN NEW PRODUCTS



More capacity for popular brands . . .

is provided by 10 double-storage columns. Behind them are 10 standard columns. Double columns hold two stacks of cigarette packs; rear stack is vended first and when it is down to two packs, the front stack is shifted on top of them. Columns are converted with L-shaped adaptor blades to hold either regular, king-size or crushproof packs; one column holds the flat, hard box. Eight-column match dispenser holds 480 match books and automatically clears itself of jams. Brands are selected with pushbuttons aligned across top of machine. Coin mechanism can be removed after price-circuit plug is disconnected.

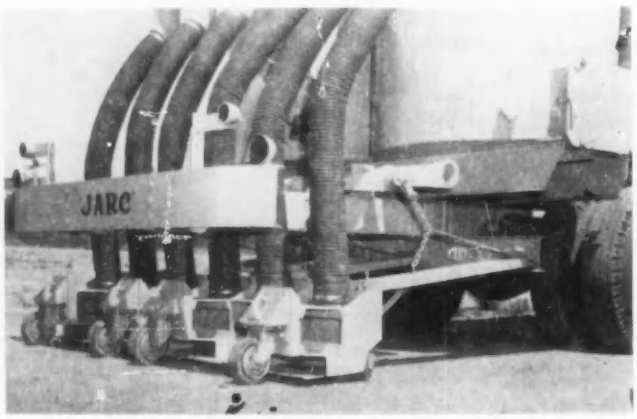


Selector buttons close circuit . . .

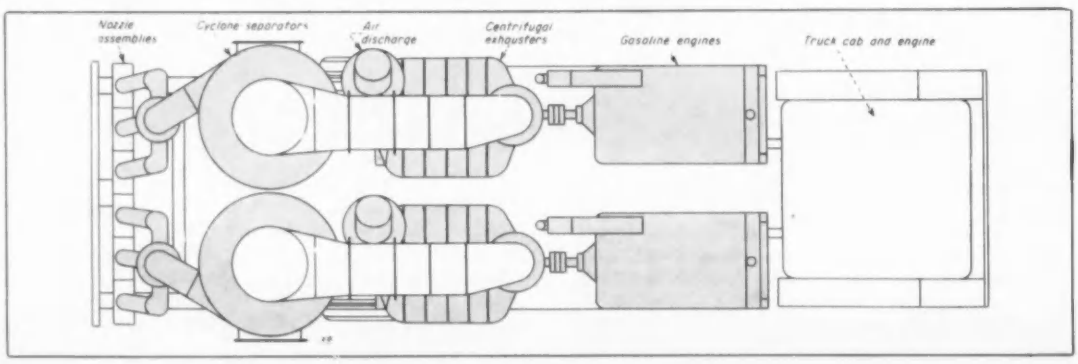
to motor that drives delivery carriages. These deliver a pack of cigarettes, collect money from the coin bucket, dispense matches, and return totalizer to zero credit position. Brand-selection circuit is energized momentarily and includes solenoids for pack-pushers, coin-return unlatch mechanism and motor starting switch. Energizing these solenoids latches a pack-pusher in the raised delivery position, prevents operation of the coin-return mechanism and initiates the delivery cycle by energizing carriage drive motor. The moving carriages close a holding switch in the motor circuit. If neither vend-flap switch is opened by a moving cigarette pack, the empty sensing solenoid is energized—this prevents collection of money from coin bucket, and energizes a signal lamp. Buyer can initiate a new cycle by selecting another brand, or he can collect his deposit.

Unusual Cleaner from Usual Parts

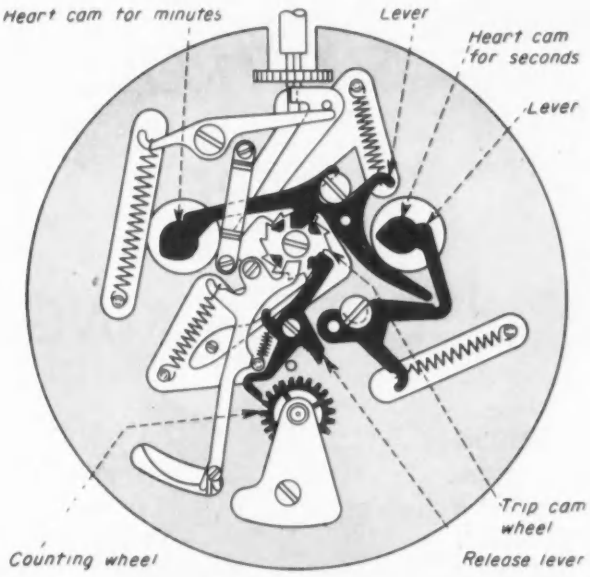
When engineers at U. S. Hoffman Machinery Corp. designed an aircraft runway cleaner, they chose standard products that could be grouped to obtain required air flow capacity, rather than design special equipment of larger size than available commercially. Their decision led to a compact, dependable vehicle and required little increase of spare parts inventories.



Airfields handling jets . . . will use this mobile vacuum cleaner to remove objects that might be sucked into jet engines, damaging or destroying them. (Estimates place repairs resulting from this damage at over several million dollars per year.) The cleaner is 30 ft long, weighs 15 tons and removes debris from two million sq ft of runway surface in about eight hours. Vacuum equipment is mounted on a standard truck chassis, selected for its cab-over-engine design. The five-stage centrifugal exhausters are driven by industrial gasoline engines. Exhausters and cyclone separators are made by Hoffman. Cleaner will sweep an 8-ft swath at speeds from 15 to 25 mph. Nozzles are raised hydraulically when not in use.



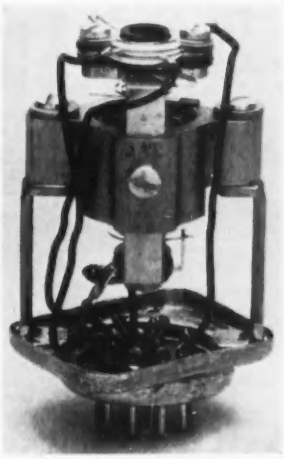
Watch Shows Time to Tenths of Seconds



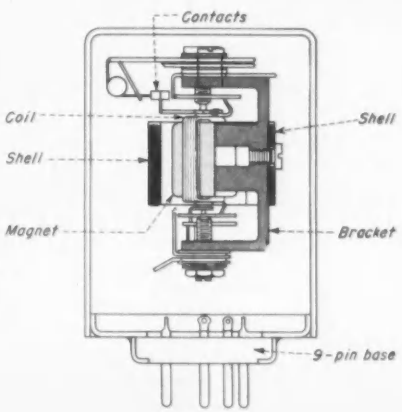
A stop watch readable directly to tenths of a second has been developed by the Junghans Watch Co., Schramberg, Germany. For continuous reading, tenths are indicated on a 120° sector of a three-pointer dial.

Minutes, seconds and tenths . . . are on separate dials so no pointer can hide another. A hood covers all but 120° of the tenths dial and always hides two of its three pointers. The three-pointer hand is on the shaft of the counting wheel and requires no intermediate gearing; its zero position is indexed by one long gear tooth. Zero positions of minute and second hands are indexed by heart cams and spring loaded levers.

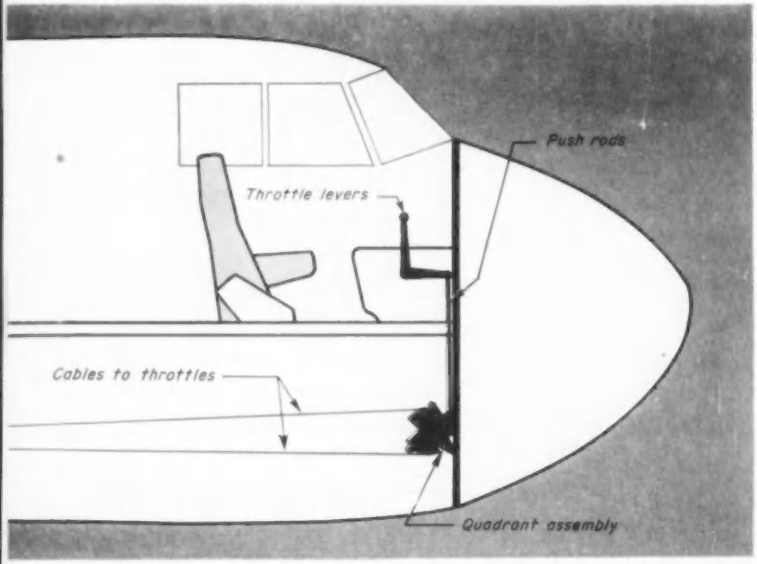
Relay Resists Vibration



Redesigning parts with higher natural frequencies has increased vibration resistance of this sensitive meter-relay. Powder-metal and investment-cast parts replace stampings, reducing machining and assembly costs, and improving ability of meter to hold calibration.

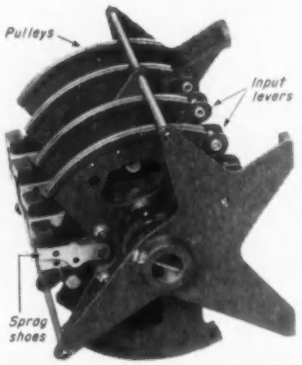


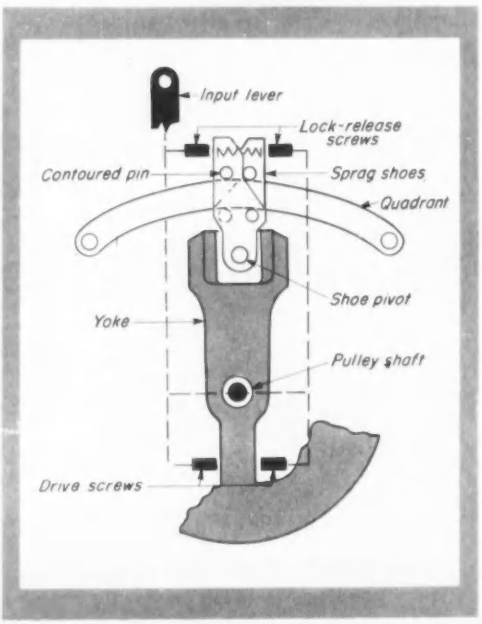
Shell surrounding magnet . . . is a powdered-iron part instead of a stamping. Its greater mass and rigidity reduce amplitude of vibrations transmitted to coil assembly. Bracket supporting the magnet and coil is an investment casting that replaces a stamping. Magnet and bracket are aligned by a slot in the shell; close fits are obtained without machining these mating parts. Alignment does not vary with assembler's skill. The model 126 VHS meter-relay is made by the San Gorcinto, Calif. Div. of Assembly Products Corp.



CONTROLS ARE SELF-LOCKING

Throttle controls on the multi-engined Lockheed Electra required an irreversible mechanism to prevent creep caused by load forces and vibration. Friction clamps were ruled out; they required an extra manual operation for locking and release, and would creep under vibration. Reid Metal Products, Inc., Burbank, Cal., designed this two-directional sprag device — a quadrant assembly operated by push rods from the throttle levers.





Cable pulleys move independently . . .
and are locked by separate sprag mechanisms. Each bi-directional sprag consists of two shoes pivoted in a yoke on the output pulley. Each shoe carries two pins contoured to the quadrant arc, which is described about the pulley axis. Pins are positioned on opposite sides of the shoe centerline; when shoe rotates, the pins describe arcs with radii shorter than that of the quadrant and either wedge against it or move away. Shoes are spring-loaded in the locking direction. Load forces at the shoe pivot produce couples at the contoured pins, clamping them to the quadrant. Throttle lever motion unlocks shoes and rotates pulley. Clearance between operating lever and pulley allows ½-to-1° lost motion in either direction.

LESS NOISE FROM SMALL ENGINES

ROY KAMO, *Research Engineer*

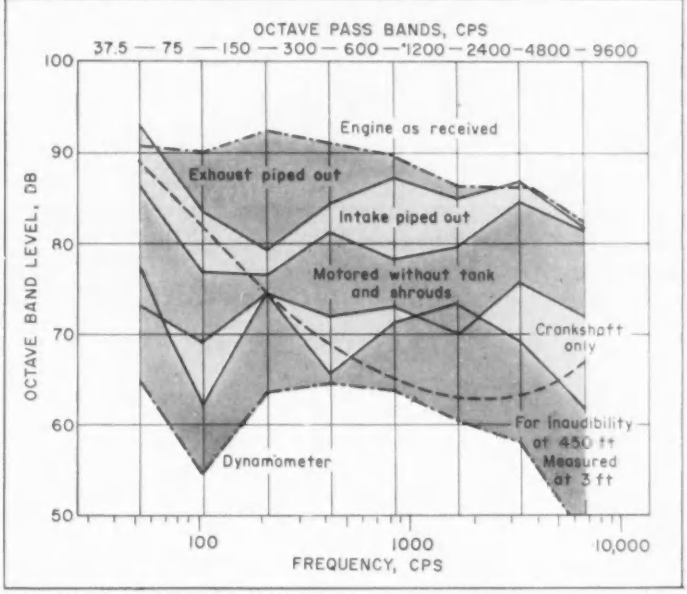
and

FRANK IWATSUKI, *Research Engineer*

Armour Research Foundation

Gasoline engines, both 2- and 4-cycle, can be silenced to acceptable noise levels by applying proved acoustic principles described in this article.

HOW A NOISE SURVEY IS MADE



Step	Noise Source Measured	Procedure
a	Over-all	Engine operated under power as received
b	Exhaust	Pipe out exhaust gas
c	Intake	Pipe in intake air
d	Combustion	"Motor" engine at given speed, using external drive motor
e	Gas tank	Remove gas tank and motor engine
f	Fan shroud	Remove fan shroud and motor engine
g	Cooling fan	Remove flywheel and motor engine
h	Poppet valve	Provide negative tappet clearance
i	Tappets and valves	Remove tappets and motor engine
j	Cam gear	Remove cam shaft
k	Ignition breaker	Remove ignition cam

Everywhere you turn nowadays a small gasoline engine putt-putts away at some useful task. Lawn mowers, chain saws, golf carts, power generators, and pumps labor noisily from backyards and lawns—to the growing irritation of a noise-conscious public. Legislative action follows, and more restrictive zoning standards come in. But with a systematic test procedure, followed by redesign of muffler, intake silencer, fan and mechanical components, small-engine noise can be reduced to meet zoning standards or acceptable levels.

The test procedure is fairly well standardized: By-pass each noise contributor in the engine in succession and make a noise-spectrum analysis after each such elimination, as shown in the table and chart on this page. Then make a shake test, in which the engine and its components are excited externally to find mechanical resonances and critical speeds.

Engine noise can be classified as either aerodynamic or mechanical noise. Exhaust, intake and blower account for the aerodynamic noises. Mechanical noise comes from vibrating structural members, valves, gears, cams, and ignition system.

(continued on next page)

Total noise level . . .
as it was reduced in successive elimination tests on a 2½-hp 2-cycle engine. Measurements were taken 3 ft from intake side of engine.

Three general principles apply in noise reduction: Eliminate the source, isolate sound and vibration, and confine or absorb radiation. Eliminating the source is ideal, but if not possible or practical, then sound-isolation should be used. Sound absorption is used only where other methods are impractical. It is better to stop noise at the source than to isolate or absorb it later.

EXHAUST NOISES

Sudden release of high-pressure engine exhaust gas into the atmosphere is the dominate noise-maker. The source cannot be eliminated or isolated; this noise must be confined and absorbed in mufflers. But attempts to reduce exhaust noise below other engine noise sources will result in higher back pressure and larger muffler without contributing to lower over-all noise levels.

Effective mufflers can be designed using the analogy of an electrical low-pass filter. These filters pass frequencies below a given value called the cutoff frequency, and reject higher frequencies. Cutoff frequency f_c for any muffler is determined from analagous equations for the equivalent electrical circuit. Reduction of noise, attenuation A, at a frequency f above the cutoff frequency is:

$$A = 17\,m \ln\left(\frac{2f}{f_c}\right)$$

where m is the number of muffler chambers.

Single-chamber mufflers are usually not adequate for reduction of high-frequency noise. Therefore, two chamber mufflers are sufficient except when extreme silencing is desired. They are simpler to build and easier to clean than mufflers with three or more chambers. Total muffler volume is seldom less than 10 to 12 times engine displacement.

An initial-expansion chamber between exhaust ports and silencer will further improve noise reduction. Chamber volume V is:

$$V = 14{,}660\,S/f_e$$

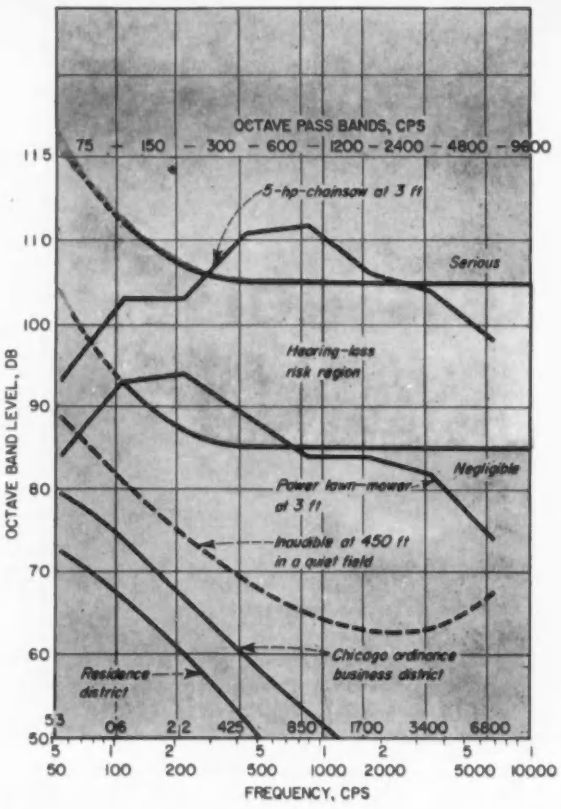
where S is valve area in sq in. and f_e is fundamental engine-exhaust frequency.

ABSORPTION SILENCERS

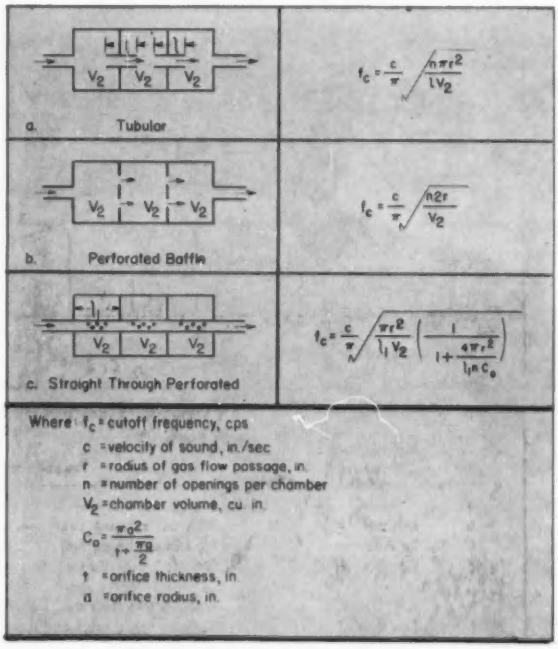
Sound-absorbing material (usually glass fiber or asbestos) around a perforated channel makes an effective absorption silencer, particularly in the range above 2000 to 3000 cycles, where noise is the most objectionable. Effectiveness depends largely on thickness and length of absorbent wall. Thickness should exceed one-quarter the wavelength of the sound. Additional length beyond a minimum value contributes little because attenuation is exponential. However, effectiveness is lost when the perforated channel becomes clogged by exhaust particles.

Back pressure is critical in 2-cycle engines because incomplete scavenging causes unnecessary power loss. The mean static pressure at rated speed and load should not exceed 6 in. of water for small, 2-cycle engines, and 10 in. of water for 4-cycle engines.

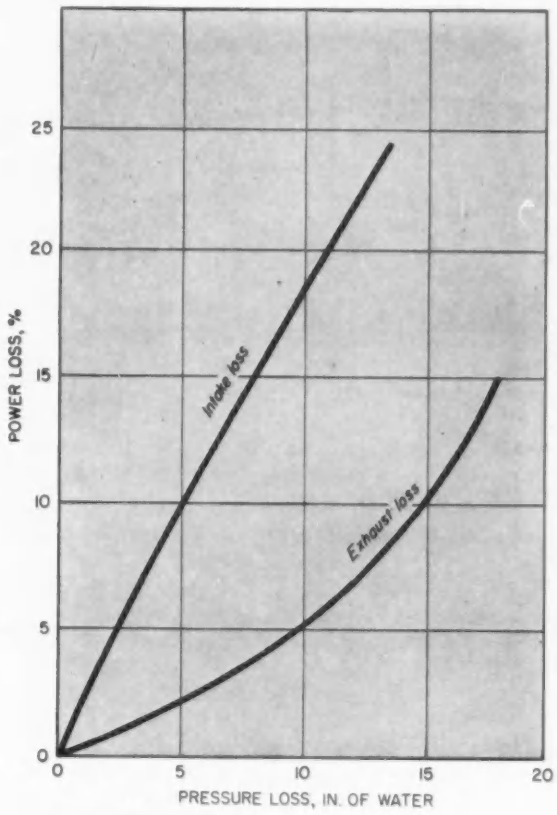
For 2-cycle engines, with their usual gas-oil mixture which tends to deposit carbon on exhaust ports and muffler, provision should be made for periodic clean-



Nuisance noise . . .
is measured here from various internal combustion engine sources, and compared with levels of noise where restrictive action steps in.


a. Tubular
$f_c = \frac{c}{\pi}\sqrt{\frac{n\pi r^2}{lV_2}}$
b. Perforated Baffle
$f_c = \frac{c}{\pi}\sqrt{\frac{n2r}{V_2}}$
c. Straight Through Perforated
$f_c = \frac{c}{\pi}\sqrt{\frac{\pi r^2}{l_1 V_2}\left(\frac{1}{1+\frac{4\pi r^2}{l_1 n C_o}}\right)}$
Where: f_c = cutoff frequency, cps
c = velocity of sound, in./sec
r = radius of gas flow passage, in.
n = number of openings per chamber
V_2 = chamber volume, cu. in.
$C_o = \frac{\pi a^2}{t + \frac{\pi a}{2}}$
t = orifice thickness, in.
a = orifice radius, in.

Low-pass filters . . .
for cutting exhaust and intake noise include these three practical arrangements. With each is the equation for determining its cutoff frequency.



Pressure drop . . .

across a silencer causes a power loss and is more critical on intake side than on exhaust. Curves are for a 2-cycle engine.

ing. Mufflers are preferably mounted vertically with the exhaust directed downward. This permits proper drainage of carbon, residue and condensation.

Air implosions into the cylinder or crankcase are responsible for intake noise. Pressures at the intake are considerably lower than at the exhaust, so noise frequencies are usually lower.

Noise reduction here is similar to exhaust-silencing. Acoustic and absorption filters work equally well as intake-noise silencers, and the same fundamentals apply. The initial-expansion chamber is unnecessary on the intake side because of lower pressures.

Two problems arise in designing an intake silencer that do not exist for the exhaust. The engine requires an air filter. This filter may help reduce intake noise if properly designed, using filter cloth or paper materials.

Pressure loss across an air cleaner-silencer combination is the other problem. It is much more critical on the intake side than on the exhaust because it results in a much greater power loss for a given pressure loss across the silencer. Pressure loss for an intake silencer-filter should not exceed 3 in. of water.

STRUCTURAL VIBRATION

Sound radiated by structural vibration comes from the cylinder head, cylinder block, crankcase housing, flywheel, gas tank, fan shrouds, baffles, and any other external engine components. Intensity of the sound depends on: the applied force causing vibration, the mechanical impedance of vibrating member, and the radiation impedance of vibrating member.

Amplitude of vibration is directly proportional to applied force and inversely proportional to mechanical impedance. Mechanical impedance is a function of the mass of the body, its stiffness and damping. At extremely low frequencies, mechanical impedance can be stiffness-controlled. Resonant frequency of a body is also dependent on mechanical impedance and can be made to differ from the forcing frequency by adjusting damping, mass, or stiffness. Changes in damping, however, shift resonant frequency only slightly.

Efficiency of sound transmission to the air is a function of radiation impedance. Reducing area of a vibrating surface causes increase in radiation impedance and a corresponding reduction in noise from the engine. To reduce coupling between air and vibrating surface, dimensions of the part should be less than a quarter wavelength of the sound in the air.

Noise caused by structural vibration can be reduced these ways:

1. Eliminate or reduce excitation source.
2. Use material with high damping qualities; for example, cast iron. Undercoat with sound-deadening material where feasible.
3. Increase stiffness by adding material. Use ribs or laminated construction where possible.
4. Reduce area of radiating surface.
5. Use vibration-isolators liberally to decouple structural members from source of vibration.

The trend today is toward lightweight, high-speed engines, which precludes extensive use of denser materials and beefed-up construction. Therefore, methods 1, 4 and 5 offer the most practical solutions.

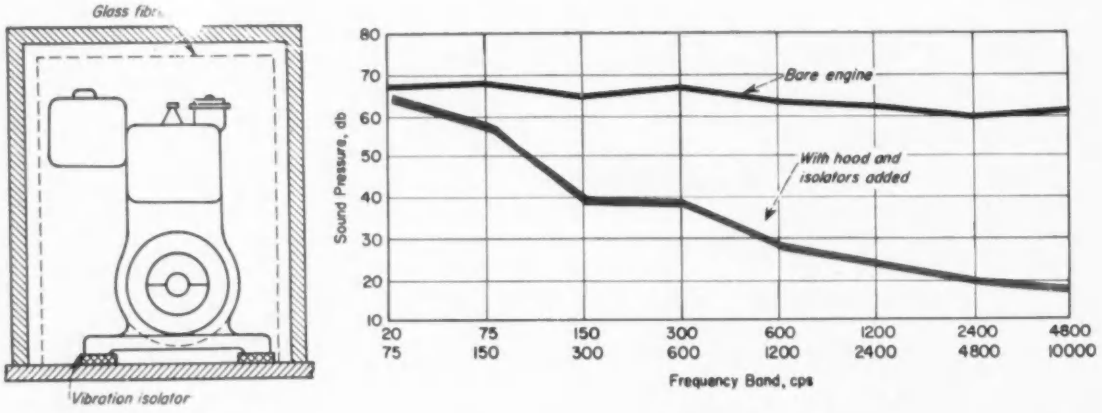
Combustion pressures and unbalanced rotating forces inherent in small reciprocating engines are prime sources of vibration. Improved balance of rotating elements can reduce bearing wear and give smoother operation. Isolation, in this case, may no longer be necessary. Proper carburetion and ignition-timing contribute to better combustion, resulting in smoother operation and reduced vibration. A cast-iron flywheel can also aid in sound-deadening as well as reduced speed fluctuations.

Manufacturing clearances should be held to the minimum consistent with good design practice. Although this is a minor consideration, it can contribute greatly towards reducing "slap" and impact during stress reversals.

VALVE-TRAIN NOISE

The 4-cycle gasoline engine with its poppet valves, camshaft, tappets and gears, is an ideal breeder of noise—to which valve impact, valve bounce, cam-drive gear impact, and tappet impact all contribute.

Zero-lash valve tappets offer no advantage over a well designed and well adjusted mechanical tappet. Similarly, stronger valve springs may prevent valve bounce, but can also create larger driving forces against the cam profile during the closing period. A reversed torque is



Silencing hood . . . combined with vibration isolators is the answer where extreme degree of silencing is required. Here is what happens when a hood is added to a 1½-hp 2-cycle engine operated at rated load and speed. Plywood hood ¼ in. thick is lined with 1 in. glass fiber.

then applied to the camshaft with resulting impact on the cam-drive gears. Repeated shocks, transmitted in this way through the camshaft and crankshaft, radiate from external surfaces, and are one of the worst sources of valve-train noise. A quick-lift, high-acceleration cam is particularly liable to this kind of noise.

Camshaft drive gears radiate noise and also cause resonant vibrations in the housing and attached parts. The latter predominates almost exclusively in 4-cycle engines.

Objectionable gear noise may result from nonuniform tooth loading, caused by fluctuating angular velocity and inertia of the rotating masses. Unbalanced elements, torsional vibrations, and reversals of torque are all contributing factors. In addition, inaccuracies in pitch and tooth profile will result in vibrations of various frequencies.

Gear materials having high internal damping qualities are preferred. Cast iron and bronze, for example, are accoustically superior to steel. Fiber, nylon and other nonmetallic gear materials should be used wherever possible.

CONFINEMENT OF AIRBORNE NOISE

As a last resort, or in cases where extreme silencing is required, silencing hoods and enclosures may be used to decouple the engine from the air. Simply a partial enclosure or sound shield, lined with absorption material, is sometimes sufficient to combat high-frequency noise and to direct sound away from low-noise areas.

Material used in silencing hoods must be nonporous for efficient sound insulation. The extent of sound attenuation depends on the materials' weight per unit area; that is, for a given wall thickness, the most dense material is the best. When light materials must be used, a double-walled hood is recommended, with walls carefully isolated from each other.

Sound-absorbing lining (glass fiber, felt, etc.) inside the hood will absorb a large part of the radiated acoustical energy. The hood, with its large surface area, can be a very efficient radiator if mechanically excited by the engine. Therefore, mechanical decoupling of engine from hood is imperative.

MINOR NOISE SOURCES

Cooling-fan noise requires attention only in extreme silencing. Fan noise is made up of rotational noise and vortex noise—both approximately proportional to the sixth power of tip speed. The fundamental frequency is equal to the product of the number of blades and the rotational speed. Harmonics are present, but those above the fourth can be neglected.

Pressure fluctuation in the crankcase of a 4-cycle engine contributes noise through the crankcase breather. This is not a serious design problem because pressure losses here are not critical.

Ignition noise is sufficiently low so that silencing is not necessary except under extreme conditions. Frequencies are in the higher octave bands and can easily be attenuated by enclosure or absorption. In many small engines, rubber-sealed weatherproofing encloses the ignition system, attenuating noise appreciably.

Handbook of Noise Control, new reference book just published, discusses in detail the problem of industrial noise control. Forty-six experts in the field of industrial noise contribute information ranging from fundamental acoustic theory to the silencing of aircraft jet-engine noise.

This new handbook includes a thorough study of all forms of noise and methods of control for each specific source. Of particular interest are chapters on measurement techniques, acoustical filters and mufflers, gear noise, bearing noise, fan noise, and anti-noise ordinances.

"Handbook of Noise Control," edited by Cyril M. Harris, 6½ x 9¼ in., 1040 pp. Published by McGraw-Hill Book Company, 330 W. 42 St., New York 36, N. Y. $16.50

LUBRICATING WITH AIR

RESEARCH Focuses on Gas Bearings

NICHOLAS CHIRONIS
Associate Editor, Product Engineering

Eleven government agencies support Franklin Institute in developing basic knowledge and design technology.

How to DESIGN Hydrodynamic Gas Bearings

J. S. AUSMAN
Engineering Supervisor
M. WILDMANN
Research Engineer
Autonetics Div., North American Aviation, Inc.

New concept in design of hydrodynamic gas-lubricated bearings leads to practical design charts.

Just why the sudden interest in gas bearings?

The principle has been known for 60 years. Ordinary air — or a specific gas such as nitrogen — can serve as a bearing lubricant, in many ways better than oil.

- It will stand temperatures above 1200 F and speeds over 100,000 rpm.
- It offers only 1/5000 as much friction as oil.
- It is clean, needs no seals to avoid contamination, and function is not affected by nuclear bombardment.

But air as a lubricant has some limitations.

- Load capacity is low.
- There is a tendency to shaft whirl.
- Close tolerances are required.

Current research at Franklin Institute is developing a technology in micro-aerodynamics; and applications in jet engines, missiles and computers are developing design criteria.

SPECIAL REPORT
Product Engineering
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RESEARCH Focuses on Gas Bearings

NICHOLAS CHIRONIS
Associate Editor, Product Engineering

Revived interest in air or gas-lubricated bearings by many designers comes from the persistent demand for bearings that can take speeds over 100,000 rpm; operate at temperatures over 1200 F; offer frictional torque resistance less than 0.05 in.-oz. under load; operate without oil in radioactive atmosphere. For such service, "gas bearing" is a better term than "air bearing" because the trend is to prevent rust by using nitrogen or one of the inert gases rather than air.

In several full-scale research programs conducted by manufacturers, gas bearings were found to perform well under all of these conditions. The bearings are relatively simple components – one type being no more than a shaft or journal turning in a hole. But problems such as instability and shaft whirl arose. Theories were developed to explain these difficulties, but they involved so many assumptions they could apply only to hypothetical bearings. Prediction of bearing performance has been poor – so that many engineers relied instead on trial-and-error test models.

Some government research agencies have also done work in this field. Last spring the Office of Naval Research established a research program in gas bearings at the Franklin Institute Laboratories in Philadelphia. In the interests of avoiding overlapping and duplication, and to insure a really comprehensive program, other departments were invited to participate in the program. Eleven government agencies are now combining their interests in gas bearings by participating in guidance of the program, and several of these are assisting in supporting it financially. They are doing only limited research, the major effort being assigned to Franklin Institute.

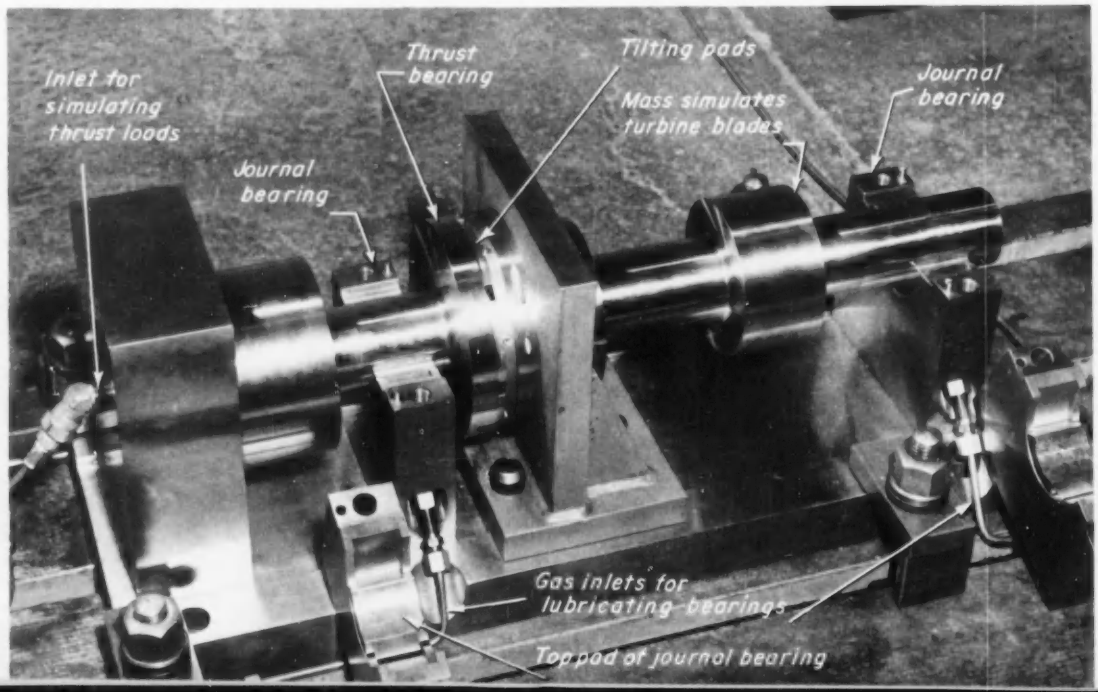
RESEARCH OBJECTIVES

Technical head of the center is Dudley D. Fuller, Professor of Mechanical Engineering at Columbia University. Mr. George Robinson is project leader of the new program. Main effort at the bearing center is "to establish a gas-bearing technology." The center is avoiding emphasis on any particular application – instead, it will cover broad areas of speed, temperature and loads. Projects already underway or at the planning stage are:

- An extensive literature survey on gas bearings, including foreign publications.
- A new theory on hydrostatic gas bearings.

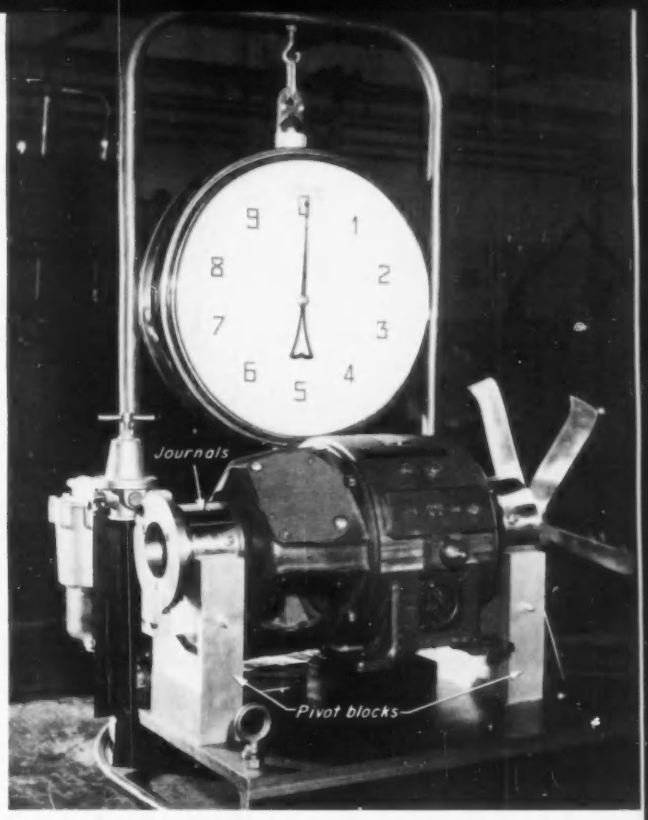
Both bearing types . . .

hydrostatic and hydrodynamic, are in this full-scale model of rotor for closed-circuit gas turbine designed by Franklin Institute Labs. Thrust bearing and two journal bearings are nitrogen-lubricated. Each journal bearing has three tilt pads; bottom two employ gas under pressure (hydrostatic lubrication). Top pad sucks in gas from surrounding atmosphere (hydrodynamic lubrication). Thrust bearing is also hydrodynamic.



Two hydrostatic bearings . . .

are in this dynamometer that uses air under pressure to obtain extremely low friction at the pivot plates. Sensitivity is so high that mercury-pot terminals are necessary to avoid unbalance from the wires.



- Solution of equations involved in hydrodynamic gas bearings.
- Experimental verification of a new theory on instability and negative force.
- Analysis of heavy-loaded hydrostatically lubricated bearings.
- A theory for predicting whirl frequencies for all types of gas bearings.
- Experimental verification and construction of attitude-eccentricity ratio curves.
- Electrical analogs to help predict performance.
- Investigation of viscous pneumatic pumps and seals for use with air-lubricated thrust bearings.
- New configurations in hydrostatic bearing design.

An advisory group of representatives from government agencies meets periodically with Laboratory personnel. This gives the Laboratory a chance to learn government-industry problems and what is being done to solve them. Reports by the Laboratory to the government agencies will be made public.

Franklin Institute successfully designed the thrust bearing on the main circulating pump on the atomic submarine Nautilus. Still in design stage are hydrostatic oil bearings which will float the 5,000,000-lb parabolic disk of the new radio telescope at Green Bank, West Va., being built for the Associated Universities, Inc. under a National Science Foundation Grant.

The Laboratory has been using air bearings for its own test equipment such as dynamometers, for quite some time, and had its own research program going when the government program was inaugurated.

WHICH TYPE GAS BEARING?

Borrowing from oil-lubrication terminology, gas bearings are classified as hydrodynamic or hydrostatic. In hydrodynamic, the load-supporting gas layer is sucked into the clearance between moving and stationary member because of pressure variations along the axial length of the bearing, as in the Kingsbury thrust bearing.

Obvious limitation is the lack of a gas layer when the bearing is started up, or at very low speeds. However, construction is simple (although tolerances are tight), and friction loss is low at high speeds. Major applications are where load is low during starting – as in gas-turbine thrust bearings. Recent experimental work shows that with heavier loads, an auxiliary air (or gas) supply can be pumped into the bearing until it builds up to speed, then this air supply is shut off.

With hydrostatic bearings, gas is pumped in under pressure from an external source. This insures a safe load-carrying film even at zero speed.

WHY GAS BEARINGS

Compared with other types of bearings – oil film, dry films and rolling bearings – advantages of gas bearings are:

Unlimited life. During operation, mating surfaces are completely separated by film of gas. Metal-to-metal contact is eliminated, and wear particles do not form.

Low viscosity. Gas-lubricated bearings have amazingly low friction properties through extreme ranges of temperature and speed.

Fluid recovery unnecessary. This leads to simpler, lower-cost designs.

Absence of oil. This avoids oil drips and leakage, and contamination of the surrounding atmosphere and associated fire hazards. For atomic energy applications, lubricant is not affected by strong radiation field.

High-temperature operation. Viscosity of a gas (unlike liquids) increases with temperature. This increases bearing load capacity. Operation at high temperature is limited only by material used in the bearing and journal.

Low noise level. Rotors can be dynamically balanced and supported by gas bearings to a finer degree than possible with even the best ball bearings – because ball bearings always present some random vibration.

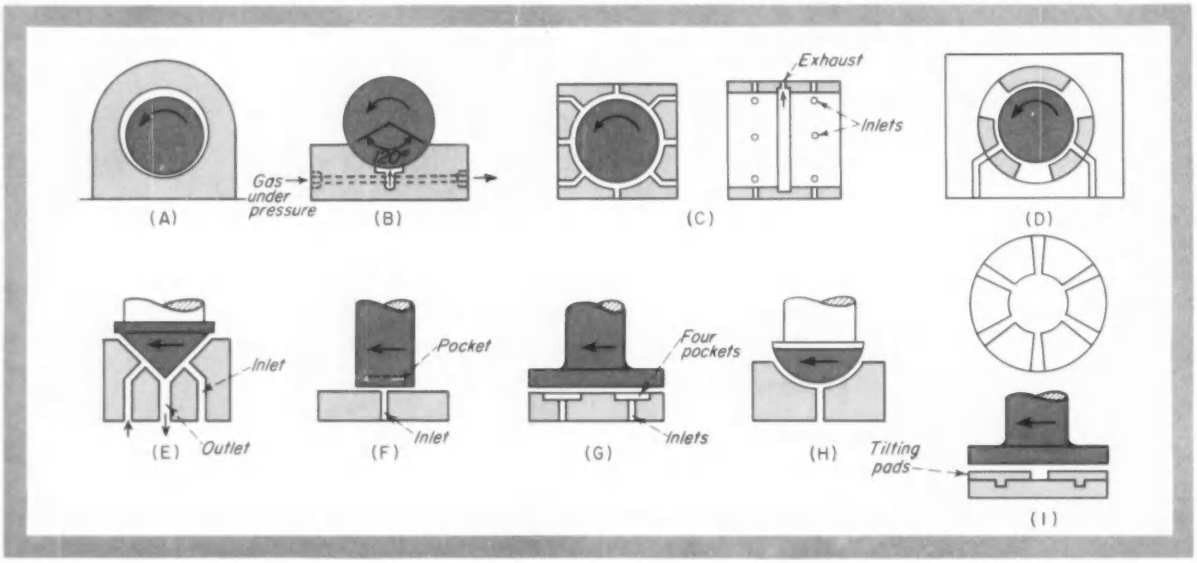
High-speed operation. Relatively low viscosity of gases means power consumed by a gas bearing is much lower than for an oil bearing of similar size. This becomes important in operations.

Geometric simplicity. Because no auxiliary equipment, such as filters, pumps or seals, are needed in a gas bearing, it is inherently simple – and particularly attractive where mechanical resonances must be avoided.

SOME LIMITATIONS

Low load capacity is the main limitation – about 15 psi of projected bearing area for hydrodynamic, but

Configurations of Gas Bearings



Now in use . . .

or under test are many configurations—a rivalry similar to that in aerodynamics over the best wing shape. Illustrated here: (A) full-cylindrical hydrodynamic, (B) hydrostatic, (C) full-cylindrical hydrostatic, (D) three-pad hydrostatic or hydrodynamic, (E) conical hydrostatic thrust, (F) single-pocket hydrostatic thrust, (G) 4-pocket hydrostatic thrust, (H) spherical recess hydrostatic thrust, (I) self-aligning hydrodynamic thrust with 6 tilt pads.

limited only by applied gas pressure for hydrostatic. This takes gas bearings out of the range of heavy-duty service.

Close tolerances in machining (0.001 in. and under) add to cost as compared with oil journal bearings. Costs may be reduced as use increases and specialized production methods are developed.

Starting characteristics are a problem for both types. In hydrodynamic bearings metal-to-metal contact takes place until the film is formed, and gases offer little boundary lubrication. Number of starts is limited.

With hydrostatic bearings, gas pressure must be built up before relative movement starts. For bearings expected to operate without periodic shut-down the two methods can be combined, using hydrostatic for starting and hydrodynamic for continuous operation.

Government Agencies in the Gas-bearing Program

Air Force Office of Scientific Research
Army Engineering Research and Development Labs
Atomic Energy Commission
Bureau of Aeronautics
Bureau of Ships
Maritime Administration
National Advisory Committee for Aeronautics
Naval Engineering Experiment Station
Naval Research Laboratories
Office of Naval Research
Wright Air Development Center

CURRENT APPLICATIONS

An upsurge is evident in the application of gas bearings to basic industrial applications, such as motors, instruments, and machine tools. Already reported, or in process of being designed, are such bearings for:

- Turntables on a dividing machine that prepares binary and encoding disks ("Air Bearing Levels Dividing Table," Apr '56, p 156).
- Small electric motors that must run continuously for long periods. This is a German application ("Gleitlager mit Luftschmierung," H. Dresher, V.D.L. Zeitschrift, Vol. 95, No. 35, Dec '53).
- Suspension of gyro-compasses — a hemispherical bearing configuration replaces ball bearing gimbels ("Water Bearings and Air Bearings," F. Gottwald, Report PB 121405, US Dept. of Commerce, July '55).
- High-speed grinding spindles requiring no lubricating maintenance over long periods.
- Magnetic memory devices in digital computers. Here the bearing maintains a tiny but constant clearance between rotating and stationary members to give a reliable, low-reluctance magnetic circuit. Oil lubrication would make power consumption of the unit too high for proper operation.
- Pumps to circulate oil-free carbon dioxide through high-temperature cooling circuit in nuclear reactors.
- Optical and other precision instruments where vibrations cannot be tolerated.
- Food processing, textile and chemical industries where absence of oil drip is highly desirable.
- High-speed compressors and superchargers where low friction, absence of oil and good high-temperature characteristics are standard requirements.

How to DESIGN Hydrodynamic Gas Bearings

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Fundamental principle of hydrodynamic gas bearings lies in the continuity principle of fluid mechanics. For the journal bearing without side flow the fluid mass rate of flow (per unit bearing width) must be constant along axial length of the bearing. Expressed symbolically, $\rho uh = \text{constant}$, where ρ is density of lubricant, u is velocity of the fluid averaged over h, and h is thickness of the fluid film.

When the journal takes an eccentric position relative to the bearing, the film thickness varies sinusoidally around the journal. This means that either or both the average velocity u and the density ρ must vary in inversely to satisfy the continuity principle. These velocity and density variations require the existence of pressure variations with integrated effect sufficient to support some load on the journal bearing.

If it is assumed velocity variations compensate completely for the film thickness variations while the density remains constant, the theory is exactly the same as that for a liquid lubricant such as oil. This incompressible lubrication is the "hydrodynamic wedge." One of its important characteristics in lubrication of journal bearings is that the min film thickness occurs 90° away from the load line.

If density alone varied to compensate for film thickness variations, while the average velocity remained constant, the point of min film thickness would occur in line with the load – as if the gas film were being compressed as an elastic solid. The high density at min film thickness must be associated with a high pressure, while the low density at max film thickness must be asociated with a low pressure. This effect is found only in gas bearings and is referred to as the "density wedge," "compression effect," or simply "compression."

Both the hydrodynamic wedge and the compression effect occur in a hydrodynamic gas bearing. The wedge produces a load-supporting component 90° away from the min film thickness, and the compression effect produces a load-supporting component in line with this film thickness. Resultant load support acts at an attitude angle between 0° and 90°.

Relative importance of the hydrodynamic wedge and the compression effect is measured by the dimensionless bearing parameter (for definition of terms, see list of symbols)

$$H = \frac{6\eta\omega r^2}{kP_aC^2}$$

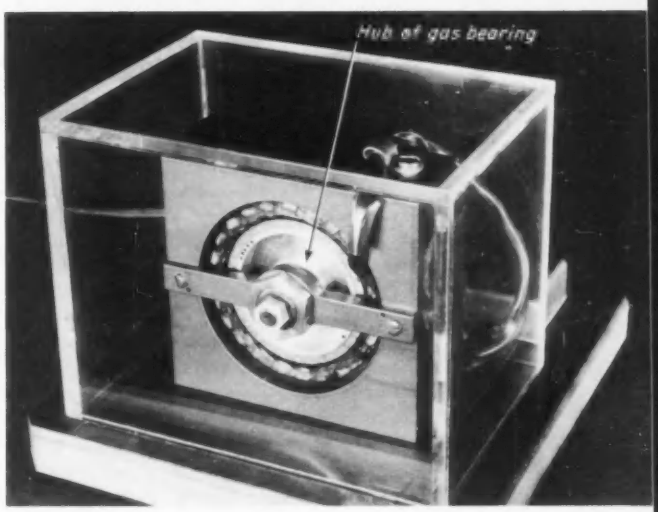
At very small values of $H(H<<1)$, the wedge effect predominates and the usual hydrodynamic theory of lubri-

MEET THE AUTHORS

The two men who put their know-how into this article have made significant contributions to the technology of gas bearings. Dr. Ausman is noted for an analysis that includes end-flow factors for bearings of finite length. Mr. Wildmann has improved techniques for evaluating such bearings, and has substantiated Dr. Ausman's concept with experimental data.

Most of their work on gas bearings has been sponsored by Autonetics, a division of North American Aviation, Inc., and presented as technical papers (Ausman, "The Finite Gas-lubricated Journal Bearing," Paper 22, London Conference, Inst. of Mech. Engrs., Oct '57; Wildmann, "Experiments on Gas-lubricated Journal Bearings," ASME Paper 56-Lub-8, Oct '56).

Now, turning to practical applications, they have jointly prepared for *Product Engineering* this design manual on hydrodynamic gas bearings.



Unlimited life . . .

is predicted for this gas bearing—a hydrodynamic type that needs no gas lines. Electrically driven, and glass-enclosed to prevent corrosion of the bearing materials, it has been operating in the laboratory at North American Aviation continuously since May, 1952.

cation with incompressible lubricants may adequately describe lubrication by gases. At very large values of $H(H>>1)$, the compression effect predominates and the hydrodynamic wedge can be neglected. The attitude angle ψ varies accordingly. For a lightly loaded journal bearing with negligible side-flow, the attitude angle is given by

$$\psi = tan^{-1}\left(\frac{1}{H}\right)$$

For this bearing (small eccentricity and no side-leakage) the load is

$$W = \pi k P_o r b \epsilon H / \sqrt{1 + H^2}$$

Side-leakage reduces load and increases attitude angle toward 90°. High eccentricity ratios increase the load higher than that indicated by the linear relationship above, and reduce the attitude angle.

When compression effects predominate $(1<<H)$ and if $k = 1$ is assumed, the behavior of a gas bearing can be expressed by three equations:

$$W = \frac{2\pi b r P_o}{\epsilon}\left[\frac{1 - \sqrt{1-\epsilon^2}}{\sqrt{1-\epsilon^2}}\right]$$

$$\psi = O$$

$$\mu = \frac{\eta \omega r \epsilon}{h_o P_o [1 - \sqrt{1-\epsilon^2}]}$$

Thus when compression effects predominate, the load capacity of an hydrodynamic gas bearing is independent of lubricant viscosity and bearing speed, and proportional to ambient pressure. In this region, behavior of a gas-lubricated bearing is completely different from behavior of liquid-lubricated ones. Noncompressible theory, even when the bearing is only lightly loaded, will not give satisfactory results.

DESIGN CHARTS

Good indication of gas bearing performance is indicated by eccentricity ratio ϵ, attitude angle ψ, friction loss μ. Usually these factors should be kept to a minimum. Once general dimensions of the bearing are known, the five accompanying charts permit speedy determination of the performance factors.

Curves based on Dr. Ausman's work (Charts 2 and 3) increase in accuracy as the eccentricity ratio approaches zero, while curves based on Katto and Soda's work (Charts 2 and 4) do not take side flow into account. To make these curves useful for all values of length and eccentricity, it is assumed that the end-flow factor determined for small eccentricities can also be used for large eccentricities; and that the initial attitude angle determines the path of the bearing inside the clearance circle. Although these assumptions cannot be completely justified theoretically, they give good results.

To determine frictional losses in a gas bearing, the coefficient of friction has been plotted in Chart 5 as a function of bearing parameter H for various values of eccentricity. As in oil-lubricated bearings, frictional force on the bearing shaft is different from force on the sleeve, except when the eccentricity ratio is zero. In gas bearings, this effect is important only at small values of H. In this region, an average value of friction coefficient is indicated by dotted lines. The coefficient of friction shown is with the end flow neglected and must be divided by the end-flow factor previously determined.

SIX STEPS IN DESIGN

Dimensions of a typical bearing are listed below. It is desired to find the eccentricity ratio, attitude angle and frictional torque.

Radius, r ..... 0.375 in.
Length, b ..... 1.75 in.
Speed, ω ..... 2000 rpm = 209 rad/sec
Radial clearance, c ..... 0.00013 in.
Lubricant (air) viscosity, η .... $(27)(10^{-10})$ lb-sec/in.^{2}
Load, W ..... 10 lb
Assume $k = \gamma = 1.4$

The assumption that $k = \gamma$, rather than unity, is based on experimental data which indicates an almost adiabatic behavior. However, the design curves are set up for various values of k.

1. Compute the bearing parameter and length-dia ratio

$$H = \frac{6\eta\omega r^2}{P_a k c^2} = \frac{(6)(27)(10^{-10})(209)(0.375)^2}{(14.7)(1.4)(0.0013)^2} = 1.37$$

$$\frac{b}{d} = \frac{1.75}{(2)(0.375)} = 2.34$$

2. From Chart 1, the end-flow factor is

$$\frac{W}{W_i} = 0.71$$

3. Now compute W_i and L

$$W_i = \frac{W}{0.71} = \frac{10}{0.71} = 14.1 \text{ lb}$$

$$L = \frac{W_i}{P_a k b d} = \frac{14.1}{(14.7)(1.4)(1.75)(.75)} = 0.523$$

4. From Chart 2, the eccentricity ratio is

$$\epsilon = 0.37$$

5. From Chart 3, $\psi_o = 48$ and from Chart 4, the attitude angle is

$$\psi = 43^0$$

6. From Chart 5, $\mu r \epsilon / c = 0.5$. Therefore the friction force acting at a radius of 0.375 in. is

$$f = \frac{0.5 W_i c}{r\epsilon} = \frac{(.5)(14.)(0.00013)}{(0.375)(0.37)} = 0.0066 \text{ lb}$$

This force could also have been computed from the frictional formula:

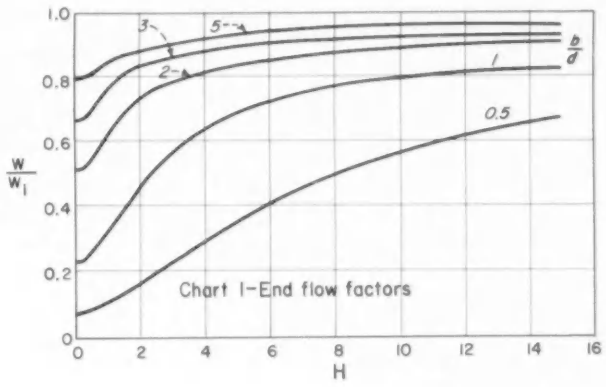
$$f = \frac{2\pi\eta\omega r^2 b}{c\sqrt{1-\epsilon^2}} = 0.00715 \text{ lb}$$

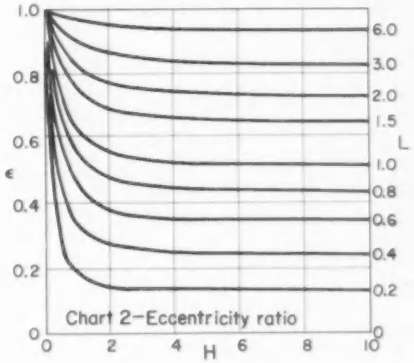
giving a friction torque of $T = 0.00715\ (0.375) = 0.00268$ lb-in.

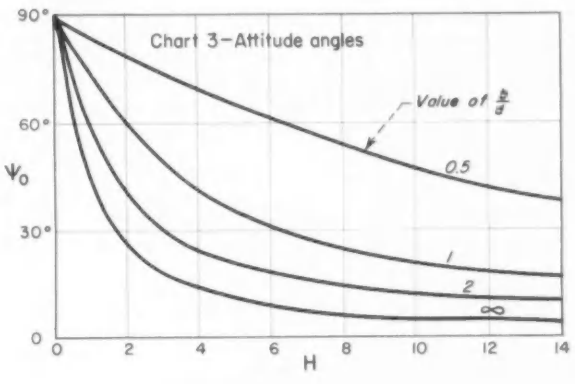
An eccentricity ratio of 0.37 is quite satisfactory. (In most applications the ratio should not exceed 0.5 – Ed.)

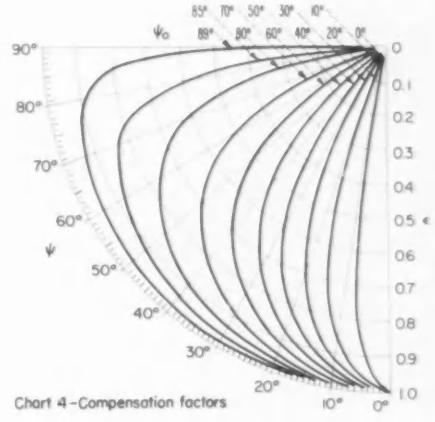
Constants chosen in this computation were from one of Wildmann's experimental bearings. The experimentally determined eccentricity ratio is 0.39 and attitude angle is 46° – reasonably near the computed values.

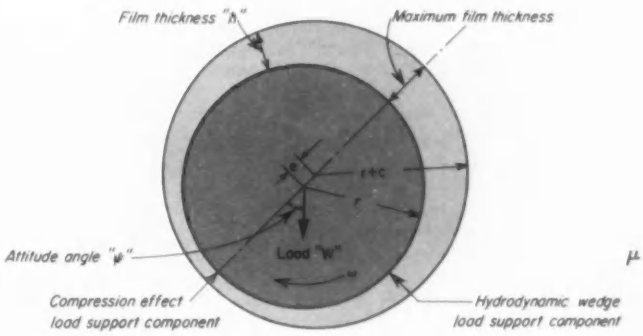
Where constants in parameter H are not known, it is usually easier to assume them and approach the solu-



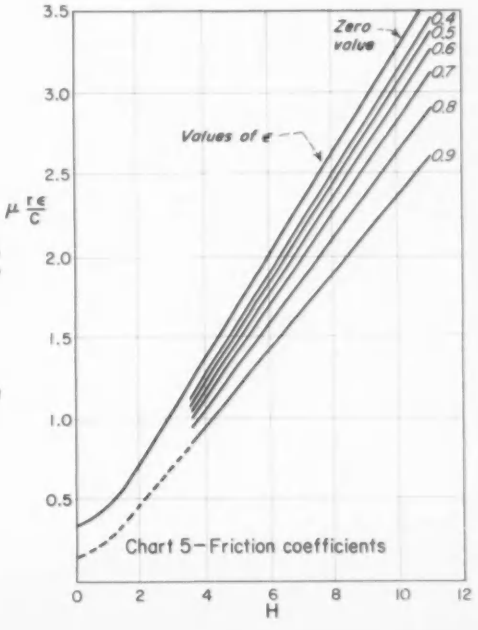








- b Bearing length
- c Bearing clearance
- d Dia of bearing
- e Eccentricity
- f Friction force on bearing
- H Bearing parameter
- h Thickness of lubricating film
- k Exponent of density in pressure-density relationship
- L Load parameter = $W_1/(K P_0 bd)$
- P Pressure in lubricating film
- P_0 Ambient pressure
- r Bearing radius
- u Average velocity of lubricant
- W Bearing load
- W_1 Bearing load without end flow
- γ Ratio of specific heats for gas lubricant
- ϵ Eccentricity ratio
- η Absolute viscosity
- μ Coefficient of friction = f/W_1
- ρ Density of lubricant
- ρ_0 Density at ambient pressure
- ψ Attitude angle
- ψ_0 Attitude angle at small eccentricity
- ω Angular velocity of bearing



tion by trial and error, performing the computations as shown.

If the frictional loss in the bearing is an important consideration, parameter H should be chosen as small as possible to reduce frictional force. A good approximation to the frictional loss can also be had from the formula:

$$f = \frac{2\pi\eta\omega r^2 d}{c\sqrt{1-\epsilon^2}}$$

INSTABILITY IS COMMON

Instability is often present in gas bearings similar to the "oil whirl" encountered in oil-lubricated journal bearings – when the shaft starts whirling in the clearance space. This is particularly troublesome with lightly loaded bearings having large clearances. The authors have found that if the ratio of radial gap to radius is kept small ($c\ r<0.0004$) instability can usually be avoided. It can be reduced by introducing ambient gas into the bearing in the region of negative pressure, but only if the direction of applied load is known. Other methods are similar to those with hydrodynamic oil bearings, such as machining axial grooves and steps in the bearing to form several regions of positive pressure, or reducing length-to-dia ratio.

Hydrodynamic bearings cannot take much load if applied in pulses with a frequency one-half the bearing spin-frequency. When rotating at 9000 rpm (150 rps) gas bearings tested had practically no load capacity when the applied sinusoidal load had a frequency of 75 cps.

CLOSE TOLERANCES NEEDED

Radial clearances in gas bearings range from 0.001 in. to 0.001 in., rather than from 0.001 in. and up as in an oil bearing. This close tolerance can be obtained by honing. It calls for careful design of the bearing supports, so static deformations within the bearing will be smaller than the clearance. Stability of the bearing materials must be considered, and large differences in thermal expansion of shaft and sleeve cannot be tolerated. Heat generated by the bearing itself can be estimated from the frictional torque formula.

MATERIALS FAVORED

Hard materials such as chrome, nitrided steel, or tungsten carbide give the best gas bearings. They are easily machined to close tolerances, and because of their hardness, there is no "smearing" of the bearing surfaces. This differs from conventional bearing design, where some smearing is desirable. The small clearances in gas bearings do not allow room for surface deformations. Corrosivity of the lubricating gas also influences choice of a bearing material – hence the employment of inert-gas atmospheres.

SURFACE FINISH

Maximum eccentricity at which a bearing can be operated and the speed at which it becomes "airborne" are influenced by its surface finish. Machining methods employed in manufacturing the gas bearings automatically give good surface finishes. But even with good finishes, it is better not to bring surfaces closer than 50 microin. For example, if clearance is 0.0001 in., max eccentricity ratio should not exceed 0.5

Special care during assembly is necessary to keep bearing surfaces perfectly clean: Cleaning fluid should not leave deposits, and foreign particles must be kept out of the bearing.

Some form of thrust support is usually required. The noncompressible theory will give satisfactory results for gas-lubricated thrust bearings as long as the bearing is not operating at extremely high speeds.

EDITOR'S NOTE:

These recent articles cover major advances in concepts, materials applications and design analysis.

New Concepts

"How to Design Ball Bearings for Water Lubrication," Oct 28 '57, p 72. Recommended materials and tips on getting best performance.

"Water-lubricated Fluid-film Bearings," Sept 30 '57, p 74. Corrosion, low viscosity and poor boundary lubrication can be controlled by proper design and choice of materials.

"Large Ball Bearings," Oct '55, p 156. Basic types in sizes of 6-in. bore and larger. Effect of speed and size of balls on capacity.

New Materials

"Material Recommendations for Special Bearing Applications," Mid-Oct '57, p F7. Charts and recommendations for ball-bearing races and separators.

"New Oil-Less Bearing Material," Jan '57, p 202. Characteristics and properties, advantages and limitations of bearings made from graphite-metal powder combinations.

New Applications

"Simplify Design with Multifunction Ball Bearings," Sep 16 '57, p 122. Examples of special ball bearings, each built to do more than one job.

"Unusual Applications of Miniature Bearings," Nov '56, p 184. Ball bearings in slides, cam followers, pivot seats, gear reducers.

Design Analysis

"How to Reduce Shock Loads in Bearings," Sep 16 '57, p 72. Equations and tables for estimating shock capacity; roundup of methods for reducing shock and overload.

"Stresses in Large Rings Bearings," Feb '57, p 160. Formulas, graphs and sample calculations.

"Why Bearings Fail," Oct '56, p 167. Charts giving symptoms, causes and remedies of failures due to poor design, mechanical abuse, overload, neglect, improper lubrication, imperfect manufacture.

"Sleeve Bearing Failures," Mid-Oct '56, p E2. Analysis of failures caused by fatigue, wiping, corrosion, wear, scoring and erosion.

"Bearing Loads on Geared Shafts," Mid-Oct '56, p E6. Employing vector diagrams for rapid analysis.

"Integral-seal Ball Bearings" Nov '55, p 179. How to select combination of bearing and seal for maximum life and performance.

"Sleeve Bearing Design, " Aug '55, p 134. How to select design parameters for optimum combination of load capacity, temperature, power loss, lubricant flow, vibration and turbulence.

A-plane Down but Not Out

WASHINGTON—After 10 years of blowing hot and cold on development of nuclear-powered aircraft, the Department of Defense has shelved most of the project as a result of (1) public clamor for speedy missile-satellite success, (2) budget economics, and (3) questionable strategic values.

However, this lagging interest doesn't sound the death kneel for atomic-powered aircraft. General Electric is still working on a joint Air Force-AEC contract to develop a nuclear-aircraft propulsion system, and Lockheed and Convair are developing an airframe. Private industry and the AEC will still support a modest program, if only for commercial application.

But Pentagon officials need a bird in the hand, and the nuclear-powered airplane is still deep in the laboratory bushes. Problems of radiation-shielding weight, and effective reactor materials are far from solved. And developing a strategically effective aircraft will take three years once the basic problems are worked out.

A government official told PRODUCT ENGINEERING this week that the U. S. could have an atomic-powered aircraft flying today, for propaganda purposes, but it would have little other value. Of course, a supersonic, nuclear-powered airplane would be valuable as a bomber or patrol craft—the military predicts heavy reliance on manned planes for years despite rush to missiles.

The first atomic aircraft will be dual-powered. Take-off and landings will be by conventional fuels. Once the plane is clear of populated areas, nuclear power will take over. Eventually, conventional fuels can be eliminated. Only last year the Pentagon junked a plan to operate a plane on nuclear energy at slower speeds, switching to chemical fuels for supersonic speeds.

The A-plane-development program was first approved about 10 years ago with creation of NEPA (Nuclear Energy for Propulsion of Aircraft) and the hiring of Fairchild Engine & Aircraft to make a feasibility study. At that time, the military hoped to design a complete weapons system around A-planes.

By 1951 Fairchild had recommended going ahead with the program, and GE and Convair were given contracts to build a propulsion system and airframe. But in 1953 the military, in a sharp reversal, all but killed the program. But the AEC interceded.

In 1955 GE and Convair combined to get a rough nuclear engine airborne to determine radiation effects at varying altitudes, though the reactor did not power the plane. Since 1956, work has progressed steadily. How nuclear plant might be installed by remote control is shown in a GE sketch, right.

Now Pratt & Whitney's contract to build the J-91 jet engine for use in an atomic-powered plane has been cancelled. C. L. Johnson, Lockheed vice president of engineering and research, commented, "Withdrawal of these funds makes the outlook cloudy." Said Robert E. Gross, Lockheed board chairman and chief executive officer: "Unless A-plane production is started soon, we'll regret the delay."

Johnson and Gross were referring to the WS-125 bomber study, called ANP-MAC (Aircraft Nuclear Propulsion-Manned Aircraft) by the Air Force. By cancelling the P&W contract, the Pentagon officially shelved ANP-MAC.

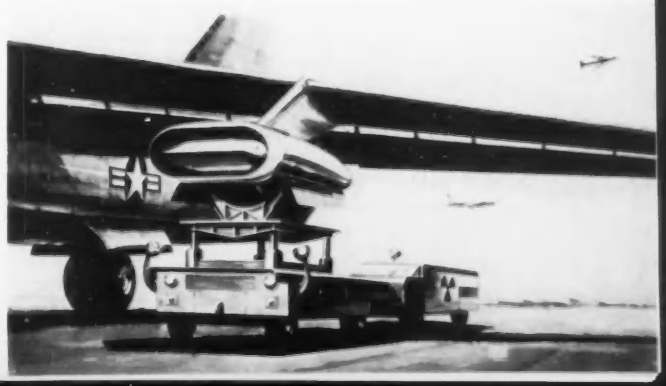
"Failure of a firm weapons system operation to materialize, coupled with current budget reviews to reduce expenditures were responsible for this decision," an Air Force spokesman commented.

Three things govern design of the potentially useful nuclear-powered plane: (1) crews must be kept as far as possible from reactor; (2) sufficient shielding for radiation protection must be installed; and (3) shielding must be divided (half near crew and half near reactor) to balance heavy weight of reactor and shielding.

But just how valuable is the atomic-powered aircraft? Granted, it doesn't need much fuel, but the military is more concerned with how long it takes an enemy to spot our aircraft. If chemically-fueled aircraft are faster, and if missiles can be efficiently guided, manned or unmanned, then the value of the A-plane pales somewhat, though not for peacetime applications.

On the other hand, manned high-flying, supersonic A-craft have evasive capabilities against defending planes or missiles. And too, mechanical control systems of missiles are still no match for the flexibility of pilot.

Though development of the A-plane has definitely been downgraded as a potential weapons system, the Air Force and AEC is still officially scheduled to spend nearly $100 million annually for the next four years on the project. No changes in these figures have been publicly announced.



The Missile's

When reasons are given for our lag in the missile (or more appropriately the satellite) race, inevitable is the cry that we do not have materials to withstand the variety of temperature extremes and other conditions encountered in the flight of a missile. Just where are these sensitive spots in a missile, what materials are being used, and what is being done to help solve the problem? Reports from a study underway to establish a criteria for the selection of materials for missiles indicate that the real material problems are inside the missile, and not so much the skin or nose.

This cross sectional view of an imaginary three-stage rocket depicts many of these crucial parts.

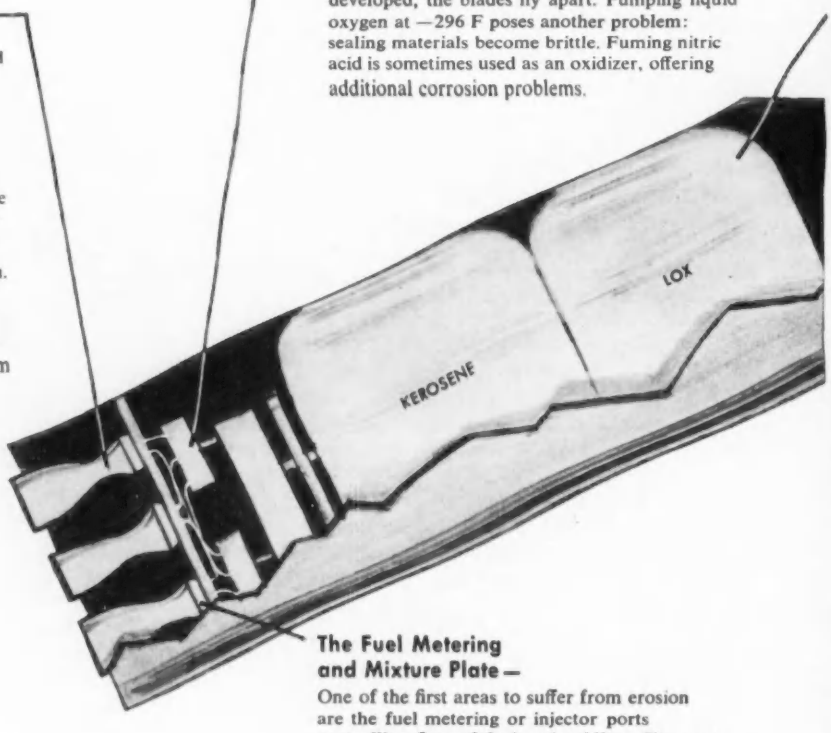
Fuel Pumps—

Usually two for each rocket stage. One pumps liquid oxygen (LOX), the other kerosene, or a jet fuel, or alcohol. Both impellers turn at better than 10,000 rpm. Rotor is about 8 in. in dia., with small blades (½ in. long). The blades are made of nickel and cobalt-based alloys, and stainless steels. Present casting and forging methods of blade manufacture are not reliable, provide poor quality control, and make it difficult to duplicate a desired blade type. High-pressure erosion is the main cause of blade failure—under the extreme stresses developed, the blades fly apart. Pumping liquid oxygen at —296 F poses another problem: sealing materials become brittle. Fuming nitric acid is sometimes used as an oxidizer, offering additional corrosion problems.

Rocket Chamber—

Alloys 4130, 4140 and others like them are the metals used here, somewhat modified to aid machinability. The material deteriorates because of extreme thermal stressses and chemical corrosion. There is an almost immediate change in the cross-section of the venturi because of the high temperature (5000 F), and thrust (30,000 ft lb). With the erosion of the materials here, it is possible for the thrust pattern of the engine to fluctuate. The first major effect is on the flight pattern. Ceramic coatings like ZrO_2, Al_2O_3, TiO and nickel plate are used most often. Another suggestion: clad with platinum. (Reports from Russia say that country is using solid platinum for critical missile parts.)

The temperature difference between the 3000 F combustion-chamber injector and the adjacent LOX at —296 F also poses distortion problems. Only a 4 to 5 in. plate separates the two.

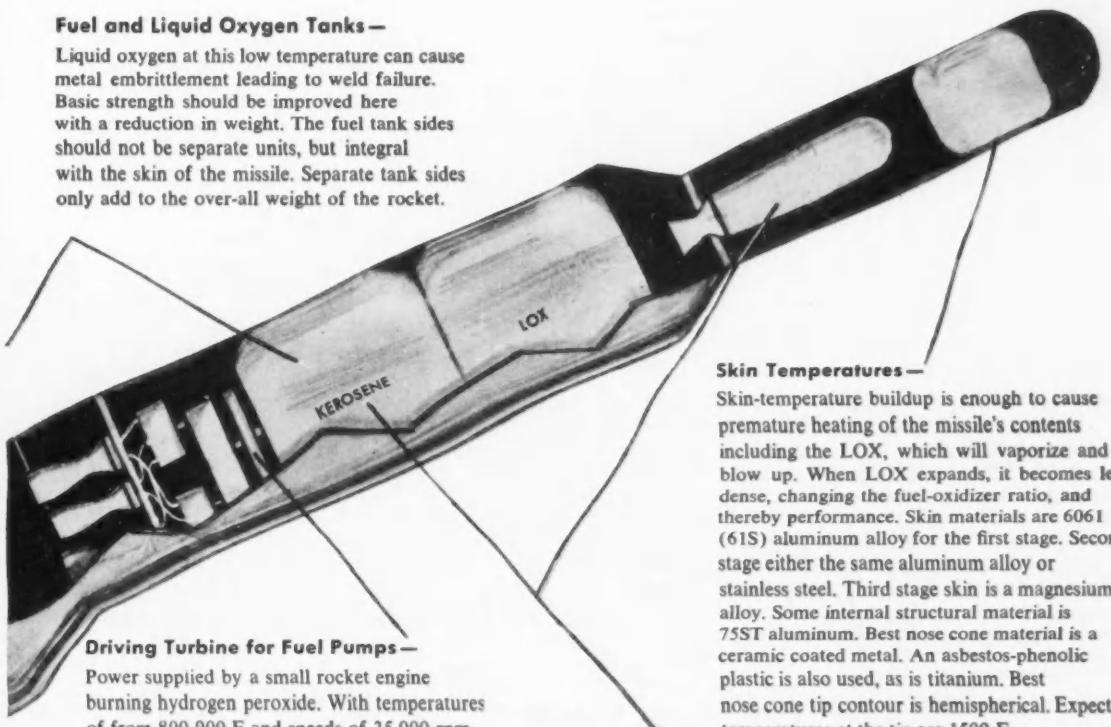


The Fuel Metering and Mixture Plate—

One of the first areas to suffer from erosion are the fuel metering or injector ports controlling flow of fuel and oxidizer. The ports cannot change their cross-sectional area and maintain a homogenous mixture. Actually, the size of the ports change because of flow erosion (3500 psi, 2500 F). Thrust values from the rocket chamber are affected immediately; this will change the rocket's acceleration. Guidance and control systems depend on a definite acceleration rate, but any trouble from this source would be eliminated by solving the basic metallurgical problems. Parts are supposed to withstand extreme pressures and temperatures for 8 min. Many fail after 4 min.

Metallurgical Miseries

Fuel and Liquid Oxygen Tanks—
Liquid oxygen at this low temperature can cause metal embrittlement leading to weld failure. Basic strength should be improved here with a reduction in weight. The fuel tank sides should not be separate units, but integral with the skin of the missile. Separate tank sides only add to the over-all weight of the rocket.



Skin Temperatures—
Skin-temperature buildup is enough to cause premature heating of the missile's contents including the LOX, which will vaporize and blow up. When LOX expands, it becomes less dense, changing the fuel-oxidizer ratio, and thereby performance. Skin materials are 6061 (61S) aluminum alloy for the first stage. Second stage either the same aluminum alloy or stainless steel. Third stage skin is a magnesium alloy. Some internal structural material is 75ST aluminum. Best nose cone material is a ceramic coated metal. An asbestos-phenolic plastic is also used, as is titanium. Best nose cone tip contour is hemispherical. Expected temperatures at the tip are 1500 F.

Driving Turbine for Fuel Pumps—
Power supplied by a small rocket engine burning hydrogen peroxide. With temperatures of from 800-900 F and speeds of 35,000 rpm, the turbine blades are subjected to thermal stress, erosion, creep, and mechanical forces. Here too the blades fly apart. Same materials are used for blades of both turbine and pump. Austenitic stainless steels and Inconel are also used but not titanium because of the oxidizing atmosphere. Other materials tried recently for turbine blades are ceramic coatings on the above materials, and copper-clad molybdenum.

Because this one turbine drives both fuel pumps, additional problems leading to pump failure grew from high mechanical stresses on the gears, and lubrication of the gear box.

Fuels Used—
Liquid fuels used are: kerosene, unsymmetrical dimethyl hydrazine, ammonia, and alcohol. Oxidizer is liquid oxygen. One source feels that the so-called "super" fuel claimed by the Russians for their second satellite is fluorine and hydrogen. Another estimate is a combination of boron and hydrogen. Russians also are known to be using alcohol—it can be made cheaply synthetically, and has a low freezing point. Liquid fuels are used almost always, certainly for the first and second stages of a three-stage rocket. Reason is its more easily controlled burning rate, and the decrease in metal erosion. Solid fuel is often used in the last stage. However, solid fuels should not be used as an initial booster to get the missile off the ground. Attachment of solid-fuel containers to the outside of the missile's hull would require extra structural supports (adding weight) to withstand the great stresses caused by thrust action of the burning fuel.

BITS AND PIECES

Free nationwide consulting service has been made available to businesses, industry, governmental agencies and associations interested in developing libraries or information centers. More than 5,000 librarians and subject specialists representing the U S, Canada, and 25 countries overseas are available for advice. For information: Special Libraries Association, 31 East 10th St., N. Y. 3, N. Y. . . . 6,000 Chinese engineers and administrative experts have been educated in Russia during the first Chinese 5-year plan for work on big projects now underway in China with Russian assistance. . . . West Germany will catch up with the U S and Britain in the peaceful uses of atomic energy, according to West Germany's atomics minister Siegfried Balke. He also stated that German nuclear science has almost reached the international level. Unsolved problem: financing the many projects. . . .

Fins For Profit

Design change to high fins on the Chrysler Corp. cars apparently has paid off handsomely. Passenger car and truck shipments in the first nine months of 1957 were up 42% over the like period last year. . . . The 40-passenger English-Fairey Rotodyne, called the world's first vertical takeoff airliner, has made its maiden flight. The plane is a combination helicopter and fixed wing aircraft powered by two turboprop engines mounted on the fixed wing which will function normally during forward flight. . . . Orders for British machine tools continued to drop during August for the 14th straight month, falling 11% below August 1956. August export orders of $3.4 million were the lowest in the last three years. . . . First control equipment for industry with 1%-max downtime guarantee is fully-transistorized, computer-data processing system, designed and built by Beckman Instruments, Inc. Replaces vacuum tubes with semiconductor devices and magnetic amplifiers to achieve reliability.

Auto Market Bright for Stainless

NEW YORK–Through increased use of multiple roll forming to laminate stainless steel over other steels, automotive producers will show "a definite increase in the use of stainless on 1958 car models," says Richard E. Paret of American Iron & Steel Institute's Committee on Stainless Steel Producers. Noting that long-predicted changes in auto design and production techniques are here, he explains that multiple roll forming is economical; it permits use of thinner gages of stainless and increases over-all yield from each pound of the shiny metal.

Paret points out that the automaker's lower finished cost per part allows broader and wider use of stainless. Body moldings particularly, he reports, are generally wider on '58 cars than heretofore. Also, standard applications of stainless will continue unchanged; window and windshield moldings, wheel discs and covers, and smaller body moldings. "Sculptured styling," Paret predicts, is expected to step up future demand for stainless by car makers.

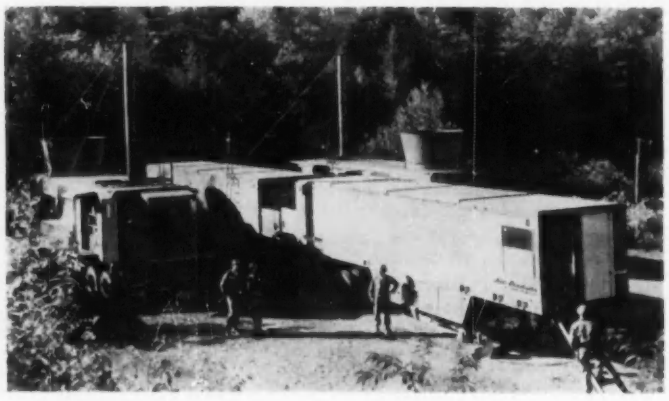
Currently, stainless moldings add not only styling, but protection of the exposed sculptured areas as well. Sculptured quarter panels and fins extend beyond the basic width of the car where they risk scratches and dents.

Chemical Milling Gaining Momentum

CHICAGO–Chemical milling, now extended to titanium, steels, stainless, nickel and cobalt alloys, has branched out of the aircraft industry.

Since its birth in 1954 the industry has grown–this year's Chicago Metals Show had four exhibitors in chemical milling (only one in 1956). Exhibitors included: Chemical Contour Corp., Downey, Calif.; National Plating and Processing Co., San Diego; U. S. Milling Corp., Manhattan Beach, Calif. and Chem-Mill Div., Turco Products, Los Angeles, (licensor). And a California firm is now considering a midwestern branch because of applications developing in the automotive and steel industries.

The process, which removes 0.001 in. per min from large areas, is competitive where metals are difficult to machine, or with sheets under ¼-in. It can also be used for making metal molds, for milling plastics, toolmaking, deburring parts, and improving surface finish.



Liquid oxygen plant . . .
can produce 20 ton (80 bbl) per day of missile fuel from 10 ton of diesel oil after a few hours for setup. The Army's new mobile unit, unlike stationary plants, requires no cooling water or chemicals. Its 4 semi-trailers operate anywhere.

NATO Viewpoints on Share-the-scientific-wealth Plan

When Pres. Eisenhower and Britain's Prime Minister MacMillan agreed to rally western allies to the cause of technological progress (translation: catching up with Russia), it was presumed other nations would come flocking.

Was this attitude justified? A pooling of technical resources and research abilities appeared to have unquestioned value.

But what of the uninvited, now invited? Was the offer too late to be of technical value? How rapidly could scientists from nations that haven't kept pace with US missile and rocket development be integrated into a cohesive, productive team?

For their reactions to these and other related questions, PRODUCT ENGINEERING through McGraw-Hill World News spot-checked leading NATO-nation scientists:

PARIS—French scientists feel the proposal to pool NATO's scientific talent could produce beneficial results—provided the proposal is more than a political gesture. Both American and French officials here say that many French developments could have been exploited to NATO's benefit much more quickly if there had been a scientific pool.

For example, low-thrust jet engines were picked up by a U S manufacturer many years after their development. In another case, the work of French scientist Rene Leduc, a specialist in ramjet propulsion, was seriously retarded for several years because he lacked funds. Recently, an American ramjet manufacturer put him back on his feet financially.

The French have also achieved high standing in electronics. The results of this work have been exploited properly.

Several European organizations have tried to pool scientific brains, but these pioneering groups lacked money and personnel to do the job as it should be done.

LONDON—British scientists, usually talkative, are reluctant to comment on possible British contributions to a scientific pool. They feel comments might be taken as claims of British superiority and might increase U S antagonism to secret-sharing.

However, it is generally felt that Britain is well behind the U S in a chemical ICBM (apart from the guidance systems). ICBM-lag has been caused by lack of money and manpower. All manpower except mathematicians are spread thinly because of the huge nuclear effort.

However, in long-term missile development where emphasis is still on theory, it is felt that British potential in pure research would prove extremely useful.

WASHINGTON—Don't look for an immediate lowering of the barriers to the exchange of scientific and technical information between the western nations.

Pres. Eisenhower put the official White House blessing on the measure in his first "chins up" talk to the nation. But, it's a difficult matter to put into effect—it will be over the long haul rather than an overnight gradually.

For one thing, Congress controls the release of nuclear weapons information and must okay its release to other countries. Other classified information will be released, but only gradually.

In addition, the US reportedly wants to stick to its present system of making bilateral agreements with western nations on military weapons development.

K. W. Gaitland, a leading missile expert, and other British scientists believe that to match Russian technology, changes more fundamental than pooling ideas are called for. There is an urgent need for both countries to tackle scientific problems at the university level, to organize the training of scientists and to coordinate curricula.

ROME—Italian physicists are unanimous in believing that a pool of engineering brains is certain to produce acceleration of over-all free-world effort.

Security noose has strangled initiative and undoubtedly has retarded progress according to several sources reached here and in Milan. Italians say, however, that except in the field of atomic measurement they have no outstanding experts who cannot be matched in the U S.

TORONTO—Many Canadian scientists believe the Eisenhower scientific pool could revolutionize Western scientific development. A typical opinion was expressed by Dr. G. N. Patterson who recently returned from Europe. He remarked, "I met dozens of brilliant scientists doing many different research projects. I am sure they would need little encouragement to work towards the common good of Western science."

Many Canadian scientists feel the veil of secrecy drawn across U S research is precisely the thing responsible for the U S lag now.

ANKARA—Pooling NATO scientific and engineering brains as proposed in the recent Eisenhower-MacMillan agreement is never too late, scientists here believe. Turkish contributions in missiles and rockets would probably be small as there is little specialization in this field here.

AMSTERDAM—Leading Dutch scientists state that the Ike-MacMillan agreement was necessary, may be im-

portant. But too few details are known. Mutual confidence is essential if the agreement is to be at all important.

The secrecy veil has been drawn too long, especially in the industrial-military sphere. European scientists have remained in the dark on key developments. Secrecy has produced little. McCarthyism has hurt.

Holland is at least equal to America in radio astronomy, hydrodynamics, exceedingly low temperatures, and superhigh tensions. Cooperation may turn some existing new theories into practice. Scientists have been sitting on their brains for lack of funds, but they have feared too much American influence, and possibility that military science would dominate pure science.

BRUSSELS—Scientists here warmly welcomed the proposed technological pooling of resources by the western nations, but there were a few misgivings. For one thing, Belgian engineers hope the program won't become hierarchic, suggesting that best results can come from those not perched on administrative summit.

Feeling here is that the Ike-MacMillan plan is a logical development of the Belgian approach to pooling and programming research to avoid any overlap. Also, European nations have made innumerable basic research contributions, but the US, with its wealth and manpower has been the nation to develop the ideas of others.

It is pointed out that the best Belgium scientific brains usually refuse offers to work in US, considering the latter's mental atmosphere not conducive to scientific abstraction. Not many top-flight scientists here, but those available should make valuable contributions. Ten men working as a team are 10 times more efficient than 10 in separate corners.

BONN—German contributions to military development of rockets and missiles will probably be slim. Military work now is limited to an engineering bureau in Stuttgart that develops antitank and anti-aircraft missiles.

Members of the former Peenemunde Rocket Research Center still in Germany have formed a rocket-technology study group, concentrating on meterological rockets. They may be able to set up research projects if asked, but these men are now holding fulltime jobs and deal with rockets as a hobby.

A recent report here claims development of a ball-shaped burning chamber that produces a 5-ton thrust within its 2-sec burning time. It may be possible to arrange these balls in a ballistic-rocket configuration with solid fuel. But it would mean an eleven-step rocket, a poor competitor to a two or three-step rocket.

As far as German scientists are concerned, they have exchanged information at scientific meetings with foreign societies for years, and are generally up-to-date on information that does not have strict military application.

ATHENS— Representative cross-section of top Greek scientists including Polytechnic University professors and members of the Greek Atomic Energy Commission feel that pooling brains and research funds is valuable.

Greeks are concentrating their major efforts on nuclear research. Lack of funds is the greatest problem, forcing many scientists to divert energies unproductively in order to earn a bare living. Teaming America's vast resources with European brains and ideas would achieve results far more startling than Russia's Sputniks.

Here's How US Gets Scientific Data from Foreign Sources

WASHINGTON—First step toward getting a freer flow of unclassified information is expected to be made by the U.S. to the NATO countries at the North Atlantic Council meeting next month in Paris. Reportedly, this will be aimed at getting a common pool of basic scientific research and technical information.

Right now, the U.S. works primarily under two organizations for the exchange of military information. One is the Advisory Group for Aeronautical Research and Development set up in 1952 under NATO to pool information on aerodynamics and aerothermodynamics. The other is the Mutual Weapons Development Program under which bilateral agreements are made for weapons R&D.

At present, the U.S. does not have a central clearing house for obtaining and disseminating foreign information. It is a point that has been raised recently by members of congress who may set one up when they reconvene next year.

The bulk of the U.S. effort toward obtaining scientific information from abroad now centers around translating technical journals. And, since most scientists are fluent in French and German, most of the translations are of Russian documents. Various government agencies do their own translations of foreign documents. Beyond this, U.S. exchange of scientific information is poor.

Efforts are made by the Interdepartmental Committee of Government Agencies to prevent duplication of translations, but there is no one place a scientist of a commercial company can turn to obtain all known information on a particular subject.

Currently, the government is considering reactivating its program of putting scientific attaches in its major embassies around the world.

COMING EVENTS

DECEMBER

1-6 . . . ASME Annual Meeting, Sheraton McAlpin and Statler Hotels, NYC.

American Rocket Society, 12th annual meeting, Hotel Statler, NYC.

2-6 . . . 26th Exposition of the Chemical Industries, New York Coliseum, NYC.

2-6 . . . 3rd International Automation Exposition, New York Trade Show Building, NYC.

9-13 . . . Joint Computer Conference, sponsored by AIEE, IRE, and ACM, Sheraton-Park Hotel, Washington.

10-11 . . . Society of the Plastic Industry, Plastics Film, Sheeting, and Coated Fabrics Division, Hotel Commodore, NYC.

18-19 . . . Maintainability of Electronic Equipment, Conference of the Electronics Industries Association, University of Southern California, Los Angeles.

BASIC RESEARCH . . .
More Practical Than You Think

This editorial, one of a special series on the importance of research to the American economy, deals with an aspect of our research program that may have serious consequences in future years — the lag in basic research.

An earlier editorial in this series noted: "The keen interest of U. S. business firms in scientific research points the way to a new kind of prosperity for our economy — a prosperity based on deliberate creativeness." As a result of the dramatic increase in industry's research expenditures, more new products will be introduced in the years 1957-1960 than in any previous four-year period.

A steady stream of new products and new processes means better values for consumers and lower costs for business. And thus it promises to sustain a high level of general prosperity that defies the old laws of boom and bust. **But, as we look further ahead, there is a danger that the stream of research discoveries may run dry because of our neglect of basic research.**

This danger was described by John Jay Hopkins, late founder and chairman of the General Dynamics Corporation: "Unless there is a revolutionary development in America of pure, not applied, science, there will come a day when there is no use in trading in your old car; because the new one is no better. The only difference between this year's television set and next year's will be the appearance of the cabinet! Scientific progress will be replaced by scientific stagnation."

What Basic Research Is

Basic (or pure) research has been characterized as the pursuit of knowledge for its own sake rather than to fulfill some practical objective. It is generally carried out in an environment which allows the investigator the freedom to follow the lead of his curiosity. The scientist in basic research, in the words of Glenn T. Seaborg of the University of California, is not concerned with "utilitarian goals, but a search for deeper understanding of the universe and the living and inorganic phenomena within it."

Impractical as basic research may seem in its initial purpose, it is an essential prerequisite to applied research and product development. A few examples will show how some of the greatest technical advances of recent years have come from basic research projects that had no immediate practical objective:

- **Radar** — an important military development of World War II with broadening commercial applications — was the outgrowth of a basic research project whose purpose was to obtain information about the height of the ionosphere, the layer of air that lies some 25 miles above the earth's surface.

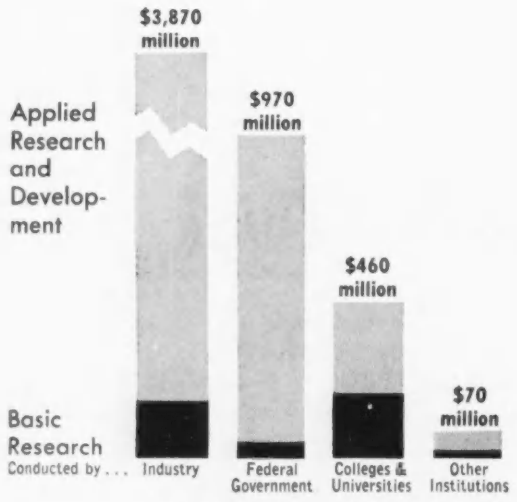
- **Transistors** — the miniature devices which are already vital components of hearing aids, pocket radios and a wide variety of industrial equipment — were invented at Bell Laboratories (research subsidiary of the American Telegraph and Telephone Company) following university investigations into the electrical behavior of solids.

- **Neoprene** — a synthetic rubber — was developed by duPont with the help of basic information provided by Father Nieuwland of Notre Dame, who discovered he could control the polymerization (the linking together of molecules) of a certain class of organic compounds.

- **Nylon** — the first of the noncellulosic synthetic fibers that have revolutionized the textile industry — grew out of fundamental research by Dr. Wallace Carothers on long-chain polymers.

(continued on page 114)

Only 8% of All Research and Development in the U. S. is Devoted to Basic Research



Data: National Science Foundation, "Funds for Basic Research in the United States, 1953"

Industry's Stake in Basic Research

Industry traditionally has relied upon colleges and universities and other nonprofit institutions for basic research; and the U. S. has long benefited from the greater emphasis placed on basic research in Europe. It is conventional to think that business cannot, and should not, do much about "ivory tower" projects which do not have immediate practical application.

However, there is not so much in this idea as is supposed. The examples above illustrate what Caryl Haskins, president of the Carnegie Institution, has called "the widespread paradox that the most important practical consequences are commonly the least sought after." Furthermore, it is certain that, without adequate basic research, industry's efforts to produce new and better products will become progressively more difficult. And our national defense, in an age of breathtaking military applications of science, will become increasingly precarious.

In the past, our economic growth came largely through expansion into new lands or through discovery and development of rich deposits of natural resources. Such opportunities are relatively limited today. The great opportunities now lie in discovering new materials and new properties of the materials we already have. **This is the job of basic research, and industry has a vital stake in it.**

The chart indicates the tiny share of research efforts in the U.S. that is devoted to basic research. **Only 4% of all research by industry, and only 8% of all research in the U.S., during the year 1953** (the latest for which information is available) **represented fundamental research to add to overall scientific knowledge.** Even in colleges and universities less than half the research performed is basic research. At least one Nobel Prize winner has expressed the belief that we need and should work toward a doubling of the proportion of our total research effort that is devoted to basic research as soon as possible.

What Business Can Do

Without anything like a staggering increase in the total cost of its research programs, industry could do much to expand our basic research effort. Companies with big research programs should, as a matter of successful survival, be devoting a share of the effort in their own laboratories to basic research. Significantly, companies that are already doing a notable job of basic research have also made an outstanding record of translating such research into new products for industry and the consumer.

Smaller companies may rightly regard the conduct of research projects with uncertain prospects of reward as a luxury. Some basic research, indeed, never results in any tangible payoff. But, with modest contributions, small companies can still have a part in the advance of basic research. They can join together with other companies on cooperative projects. They can support basic research through trade associations and technical societies. They can help research centers in universities and other nonprofit institutions. Arrangements are available in some instances whereby business firms can pay a fee to have access to work done by university researchers.

One way or another, it is up to private business firms to see that basic research moves forward. By doing so they will be laying the groundwork for the development of the new products and technology on which their growth, and the growth of the economy, depend.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw
PRESIDENT

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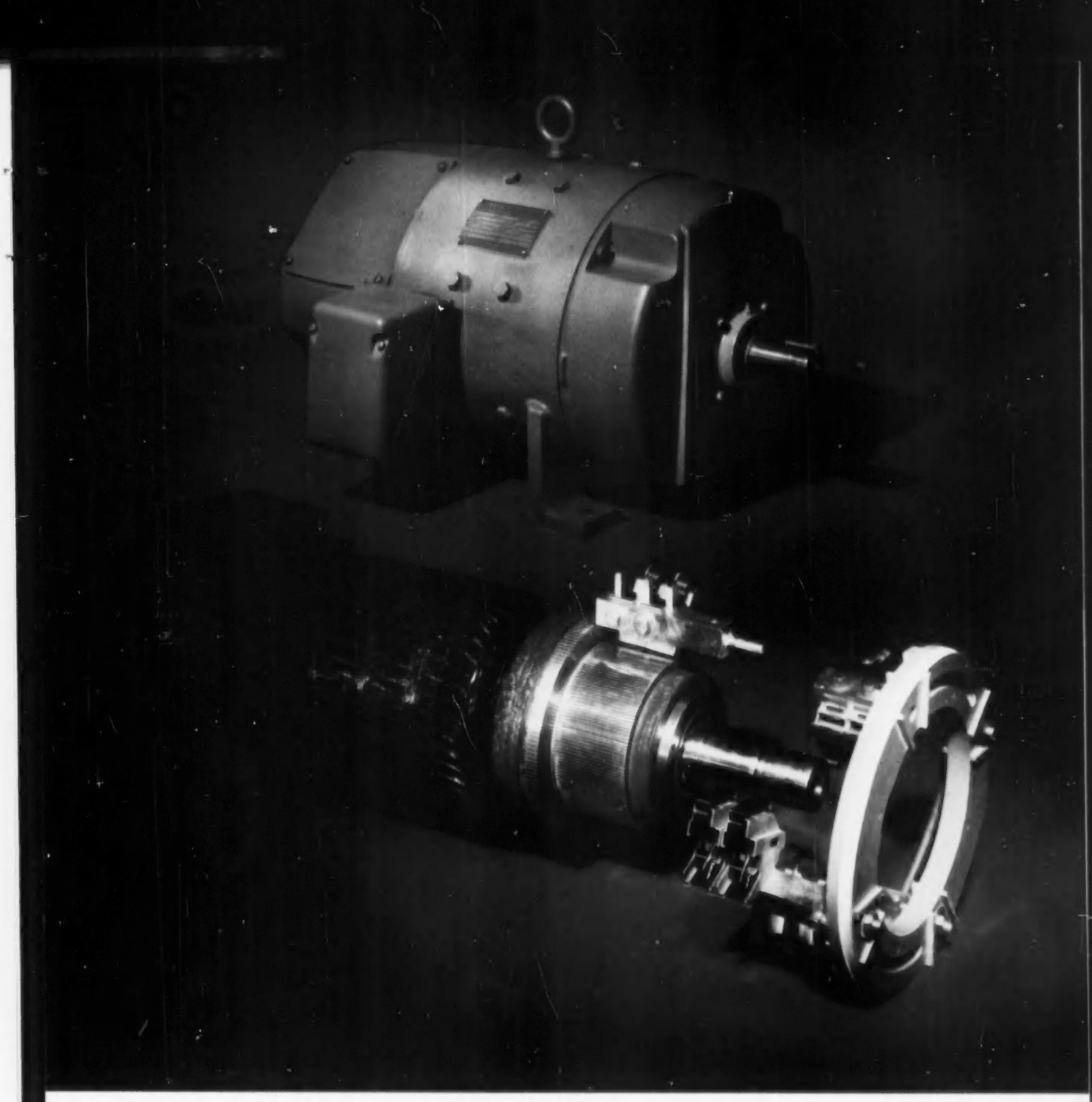

NEW GENERAL ELECTRIC DC MOTOR GIVES

Extra Power To Meet Peak Loads

*KINAMATIC** *. . . a new standard in industrial direct-current motors* . . . designed to meet the vital power load requirements of modern manufacturing methods.

Proper Design Balance . . . means unmatched commutating ability . . . the ability to deliver the short bursts of power required for quick acceleration and deceleration. Fewer turns per armature coil . . . full complement of commutating poles . . . maximum number of commutator segments, combine to permit higher peak loads.

New Brush Assembly . . . constant-pressure brush springs eliminate brush adjustments. Bronze, corrosion-resistant brush holders are mounted on square steel studs for stable operation in both directions of rotation. Molded polyester-glass yoke resists impact, intense heat and corrosion.

D-c Kinamatic Motors offer a reliable key to successful automation. Additional information is available at your nearest General Electric Apparatus Sales Office. Or, if you prefer, write for Bulletin GEA-6355, *Direct Current Motor and Generator Department, Erie, Pennsylvania.*

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Progress Is Our Most Important Product

GENERAL ELECTRIC

Each of the molded parts pictured at the right has specifications which call for special materials—often with unusual properties. All called for creative design. The volume production of these parts is proof of the thoroughness with which we approach your problems and the quality put into the finished product.

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water pump impeller

Made of special moisture resistant phenolic. Withstands the extremes of high heat and intense cold, strong torque action, and corrosion and cavitation resulting from circulation in the car's cooling system.

timing gear

Working from manufacturer's specifications, Richardson engineers developed a new material which resulted in excellent flexural strength in the web section and good bond in the laminate section—which permitted easy cutting of gear teeth with proper tooth strength. The change to plastic gears has made fabrication easy, operation is quieter, and gear life has been tripled!

radio antenna mast base

This part has good surface appearance, high impact strength, high dielectric strength, and is water and weather resistant. Material specified was black phenolic with an attractive high gloss finish.

dashboard light lens

Original part was a clear lens. Specification changes called for a translucent lens. Sandblasting the mold or the clear parts was rejected because it would add to the unit cost. Instead, Richardson engineers worked out a special light transmitting polystyrene lens which resulted in a 15% reduction of lens cost.

RICHARDSON PLASTICS
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OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

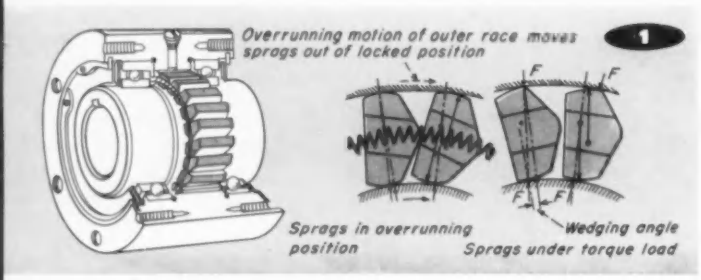
AMERICAN SMELTING AND REFINING COMPANY

Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

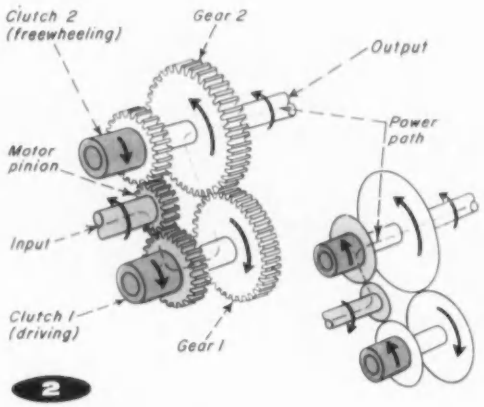
10 Ways to Apply OVERRUNNING

These clutches allow freewheeling, indexing and backstopping applicable to many design



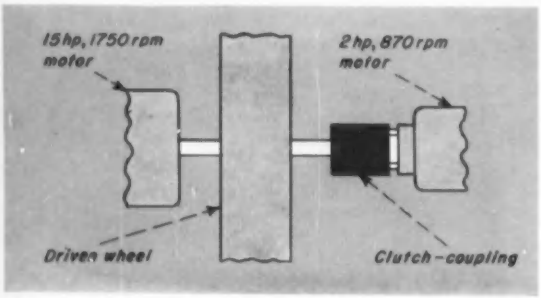
Precision Sprags . . .

act as wedges and are made of hardened alloy steel. In the Formsprag clutch, torque is transmitted from one race to another by wedging action of sprags between the races in one direction; in other direction the clutch freewheels.



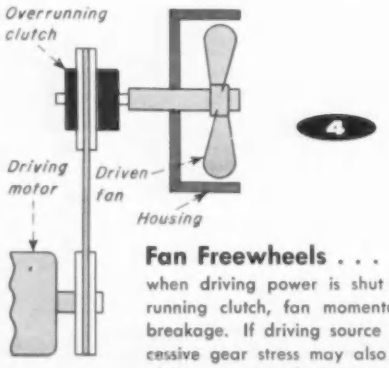
2-Speed Drive — I . . .

requires input rotation to be reversible. Counterclockwise input as shown in the diagram drives gear *1* through clutch *1*; output is counterclockwise; clutch 2 over-runs. Clockwise input (schematic) drives gear 2 through clutch 2; output is still counterclockwise; clutch *1* over-runs.



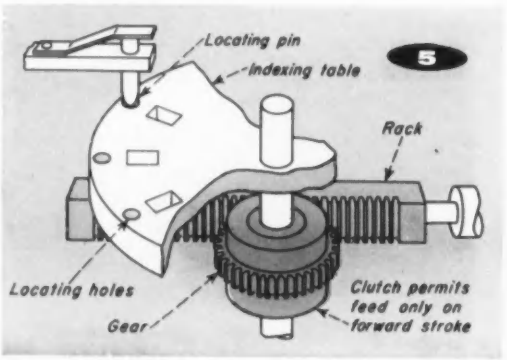
2-Speed Drive — II . . .

for grinding wheel can be simple, in-line design if over-running clutch couples two motors. Outer race of clutch is driven by gearmotor; inner race is keyed to grinding-wheel shaft. When gearmotor drives, clutch is engaged; when larger motor drives, inner race over-runs.



Fan Freewheels . . .

when driving power is shut off. Without over-running clutch, fan momentum can cause belt breakage. If driving source is a gearmotor, excessive gear stress may also occur by feedback of kinetic energy from fan.



Indexing Table . . .

is keyed to clutch shaft. Table is rotated by forward stroke of rack, power being transmitted through clutch by its outer-ring gear only during this forward stroke. Indexing is slightly short of position required. Exact position is then located by spring-loaded pin, which draws table forward to final positioning. Pin now holds table until next power stroke of hydraulic cylinder

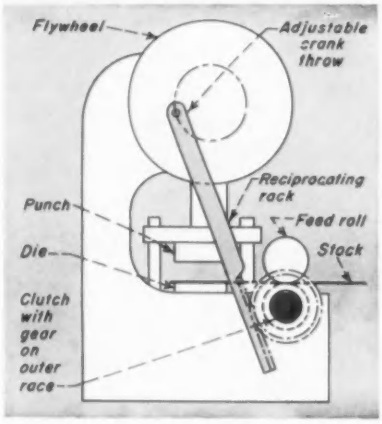
CLUTCHES

problems. Here are some clutch setups.

Product Engineering

DESIGN ROUNDUP...

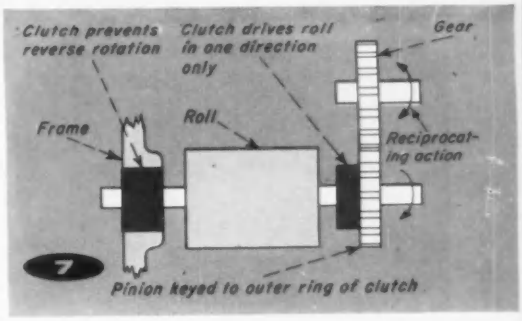
W. EDGAR MULHOLLAND, *Executive Sales Engineer*
JOHN L. KING, JR., *Project Engineer*
Formsprag Company, Warren, Mich.



6

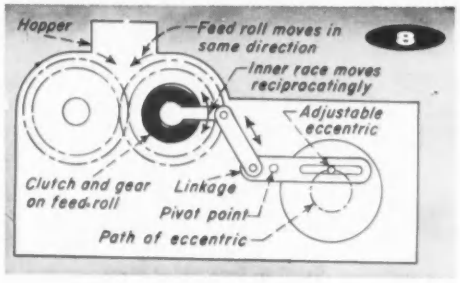
Punch Press Feed . .

is so arranged that strip is stationary on downstroke of punch (clutch freewheels); feed occurs during upstroke when clutch transmits torque. Feed mechanism can easily be adjusted to vary feed amount.



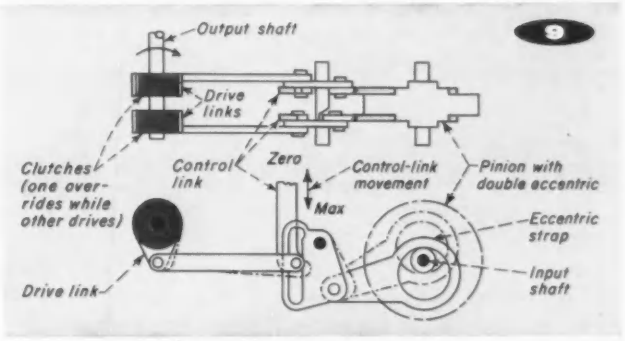
Indexing and Backstopping . . .

is done with two clutches so arranged that one drives while the other freewheels. Application here is for capsuling machine; gelatin is fed by the roll and stopped intermittently so blade can precisely shear material to form capsules.



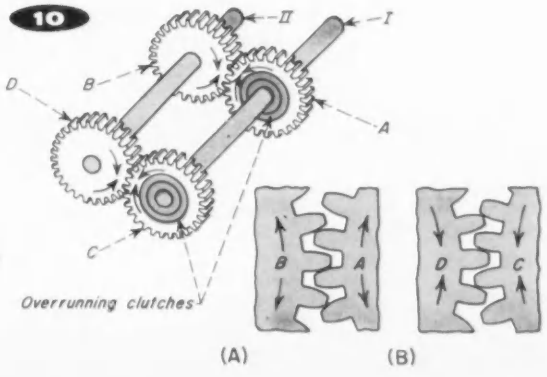
Intermittent Motion . . .

of candy machine is adjustable; function of clutch is to ratchet the feed rolls around. This keeps the material in the hopper agitated.



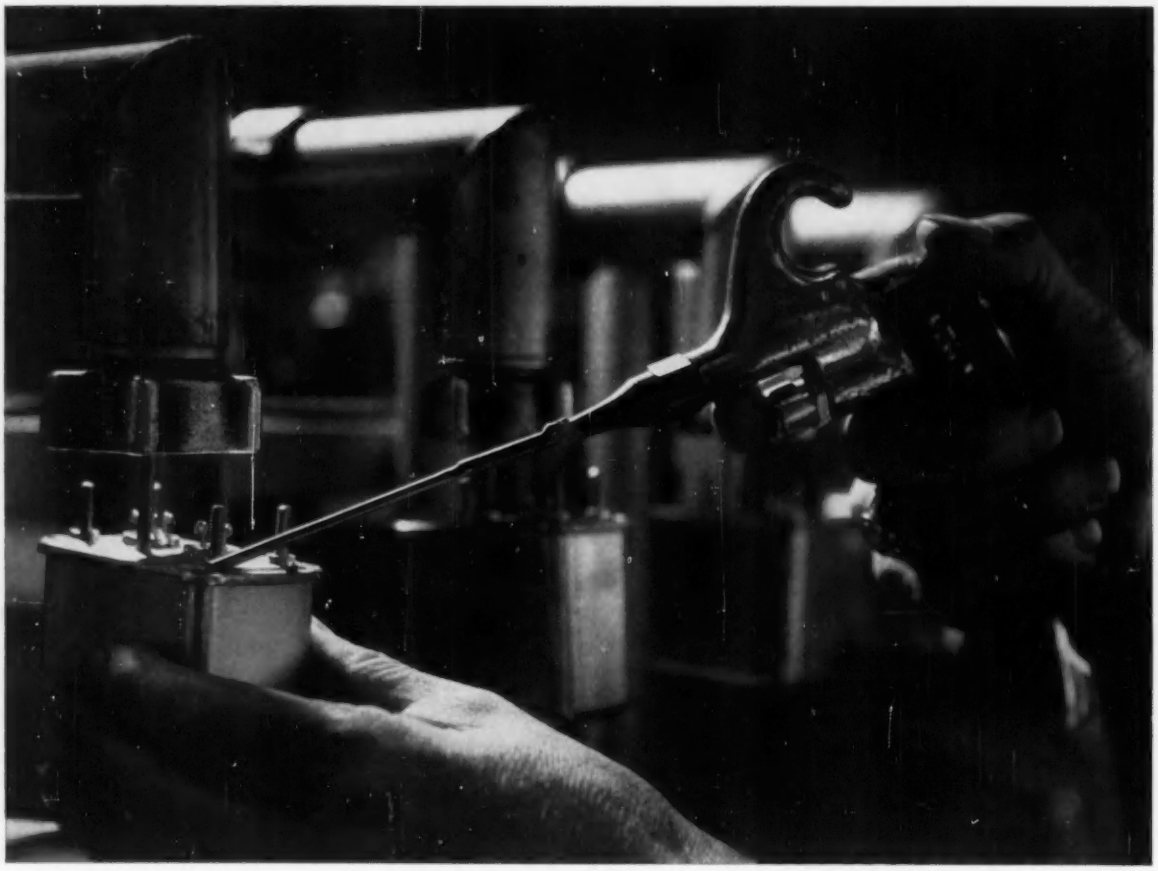
Double-impulse Drive . . .

employs double eccentrics and drive clutches. Each clutch is indexed 180° out of phase with the other. One revolution of eccentric produces two drive strokes. Stroke length, and thus the output rotation, can be adjusted from zero to max by the control link.



Anti-backlash Device . . .

uses over-running clutches to insure that no backlash is left in the unit. Gear *A* drives *B* and shaft II with the gear mesh and backlash as shown in (A). The over-running clutch in gear C permits gear *D* (driven by shaft II) to drive gear C and results in the mesh and backlash shown in (B). The over-running clutches never actually over-run. They provide flexible connections (something like split and sprung gears) between shaft I and gears *A*, C to allow absorption of all backlash.



Tracer gas is sprayed over the relay enclosure while it is under high vacuum

STANDARDS THAT DETERMINE RELAY QUALITY

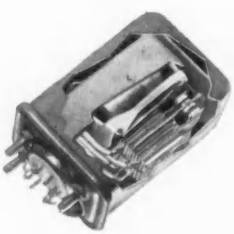
100% leak-free hermetic sealing

We reject relays with leaks so tiny that it would take 30 years to admit 1 cubic centimeter of air!

Hermetically sealed relays are safe from the dangers of human tampering, and from severe conditions of dust and dirt, sand, moisture and high humidity, fungi, salt spray and reduced air pressure. To insure this safety, however, sealed relays must be absolutely free from leaks.

That is why, at Automatic Electric, every single hermetically sealed relay undergoes a sensitive mass spectrometer test. This highly refined method of testing detects leaks so tiny that it would take *more than 30 years for one cubic centimeter of air to pass through!* To protect you, we reject "leakers" able to pass ordinary immersion tests with ease.

Thanks to uncommon care like this at every step of manufacture, Automatic Electric relays are the most reliable you can buy.



Hermetically sealed relays are available in many varieties. Write today for Catalog 4083 PD. Automatic Electric Sales Corporation, Northlake, Ill.
In Canada: *Automatic Electric Sales (Canada) Ltd., Toronto. Offices in principal cities.*

AUTOMATIC ELECTRIC

A member of the General Telephone System - One of America's great communications systems

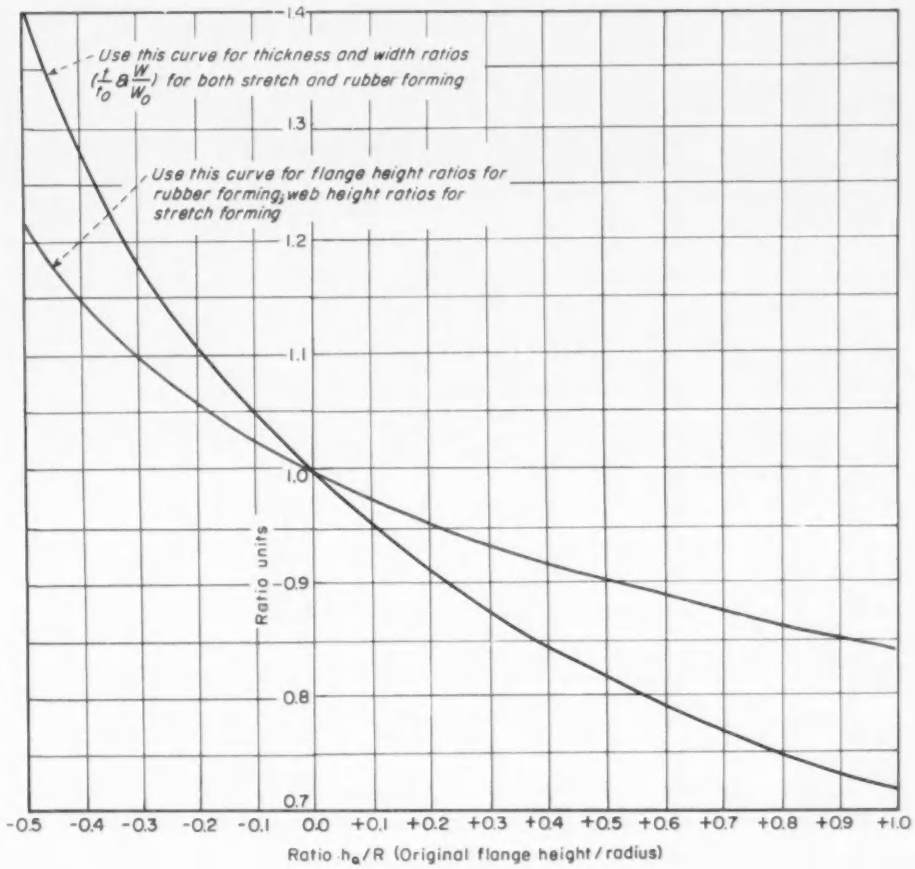
GENERAL TELEPHONE SYSTEM

REFERENCE BOOK SHEET

How to find Final Dimensions of Stretch-formed Parts

BRUCE RUSSELL *Chance Vought Aircraft, Dallas, Tex.*

Serious errors can result when thickness, flange-depth, and web-width changes are ignored in the design of stretch-formed parts. Here is the way to calculate these dimensional changes.


Use this curve for thickness and width ratios ($\frac{t}{t_o}$ & $\frac{W}{W_o}$) for both stretch and rubber forming
Use this curve for flange height ratios for rubber forming, web height ratios for stretch forming
Ratio units
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
-0.5 -0.4 -0.3 -0.2 -0.1 0.0 +0.1 +0.2 +0.3 +0.4 +0.5 +0.6 +0.7 +0.8 +0.9 +1.0
Ratio h_e/R (Original flange height / radius)

The final dimensions of stretch-formed parts can be found from the curves and formulas presented here. These aids get around the problem that contoured parts undergo dimensional changes in cross-section when formed on stretch press or rubber press. When stress calculations ignore such changes, unexpected failure of the part may occur. The problem is aggravated by new materials and production techniques that increase maximum elongation during forming; this magnifies error when strength calculations are based on the original dimension. For flat sheet or plate the thickness-elongation formula can also be employed to analyze failures in parts formed from sheet stock. All formulas give results accurate within 2%.

Negative values in the curves arise from the geometry used in deriving the equations; the numerical value of R is negative when other terms are measured in a reverse direction. Note also that h, h_e equal web height for stretch formed sections, and flange height for rubbed formed sections.

(continued on page 123)

The Royal Family of INVESTMENT CASTINGS

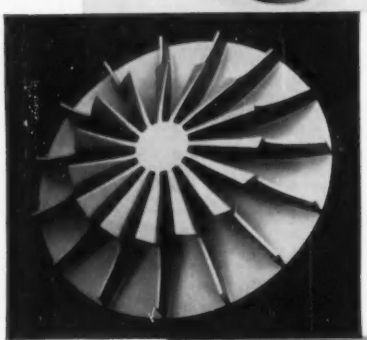
FROZEN MERCURY

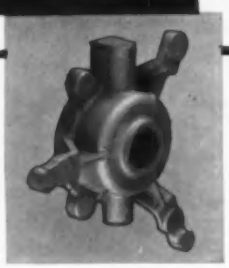
LOST WAX

Yes, there is a difference in investment casting QUALITY! Although some of the variants are not immediately detectable by visual inspection, they *are* there and they *are important!* Many of the nation's industrial leaders have selected Alloy Precision Castings — producer of "The Royal Family" of investment castings — as their primary source. Here are some of the reasons why:

- **ALLOY PRECISION** is the nation's only foundry with both FROZEN MERCURY and LOST WAX facilities under one roof!
- **ALLOY PRECISION** produces the industry's GREATEST SIZE RANGE (1/10th ounce to 100 lbs.) and choice of alloys.
- **ALLOY PRECISION'S** metallurgists, foundry engineers, laboratory technicians CONTROL every step of production.
- **ALLOY PRECISION'S** complete inspection facilities include the newest X-RAY, MAGNAFLUX and ZYGLO equipment.
- **ALLOY PRECISION** enjoys an enviable reputation for demonstrated foundry skill, consistent HIGH QUALITY and deliveries made promptly on schedule!

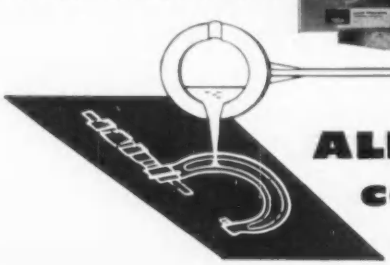
The Alloy Precision trademark (APC) on a casting is the royal stamp of approval. Guarantee the success of your investment cast parts! Send them to ALLOY PRECISION CASTINGS CO.





FREE GUIDES!

"HOW TO DESIGN, SPECIFY AND BUY INVESTMENT CASTINGS" literature includes description of Alloy Precision's modern plant and techniques. Write today! Send blue prints for quotes, design recommendations and value analysis to:



ALLOY PRECISION
castings company

Dept. 511 • 3855 West 150th • Cleveland 11, Ohio

A-1082

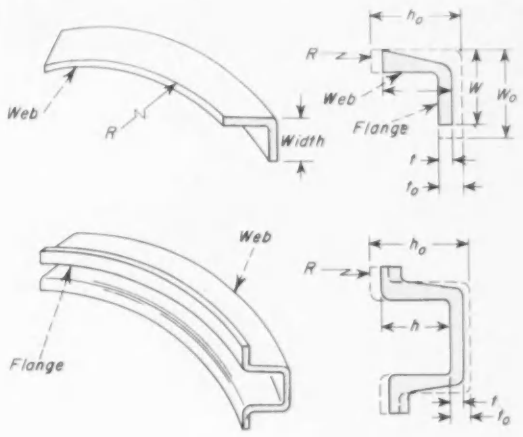
how to find
Final Dimensions of Stretch-formed Parts (continued)

STRETCH-PRESS

(entire sections stretched)

$$t = \frac{t_o}{\sqrt{1 + h_o/R}}$$

$$\frac{h}{h_o} = \frac{h_o}{4(R - h_o)}$$

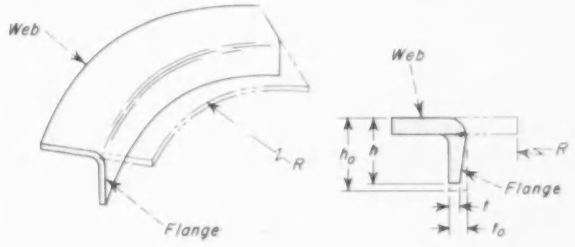


RUBBER-PRESS

(flange stretched)

$$t = \frac{t_o}{\sqrt{1 + h_o/R}}$$

$$\frac{h}{h_o} = 1 - \frac{h_o}{4(R - h_o)}$$



RUBBER-PRESS

(flange shrunk)

$$t = \frac{t_o}{\sqrt{1 - h_o/R}}$$

$$\frac{h}{h_o} = 1 + \frac{h_o}{4(R - h_o)}$$

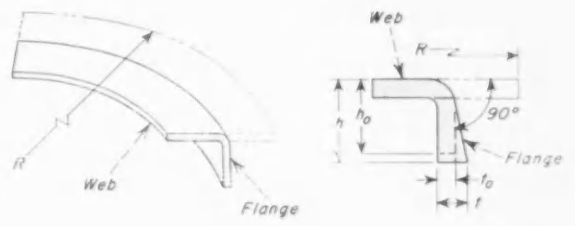
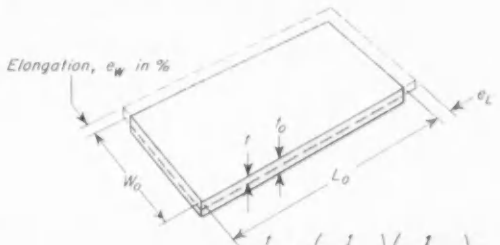
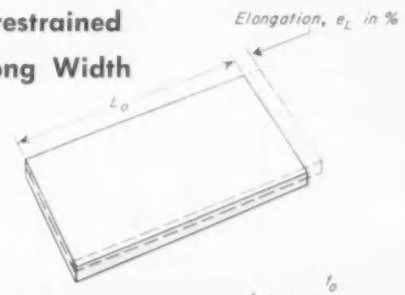


Plate or Sheet Under Triaxial Strain



$$\frac{t}{t_o} = \left(\frac{1}{1+e_L}\right)\left(\frac{1}{1+e_w}\right)$$

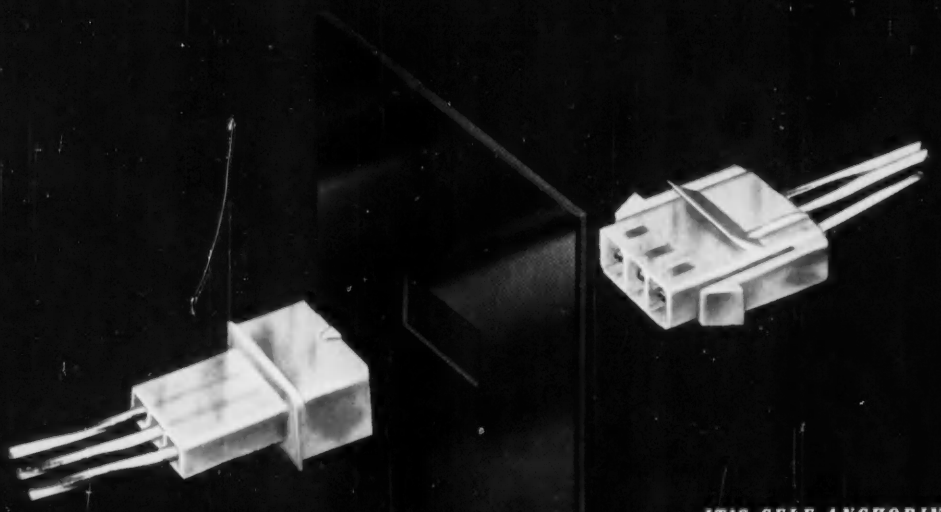
Unrestrained Along Width



$$t = \frac{t_o}{\sqrt{1+e_L}}$$

AMP-lok

the new concept in multiple connector design



. . . IT'S SELF-ANCHORING

AMP

AMP-lok eliminates the necessity for supplementary mounting devices in through panel multiple connector applications.

Additional literature and samples available on request.

AMP-lok obsoletes all it replaces because of the following design features:

- contacts are identical . . . self-cleaning recessed for safety
- finger grip engagement and disengagement
- polarized to eliminate circuit error
- wide panel thickness accommodation — one simple mounting hole required
- color-coding available

AMP-lok can be used as a safe, free-hanging multiple connector, also.

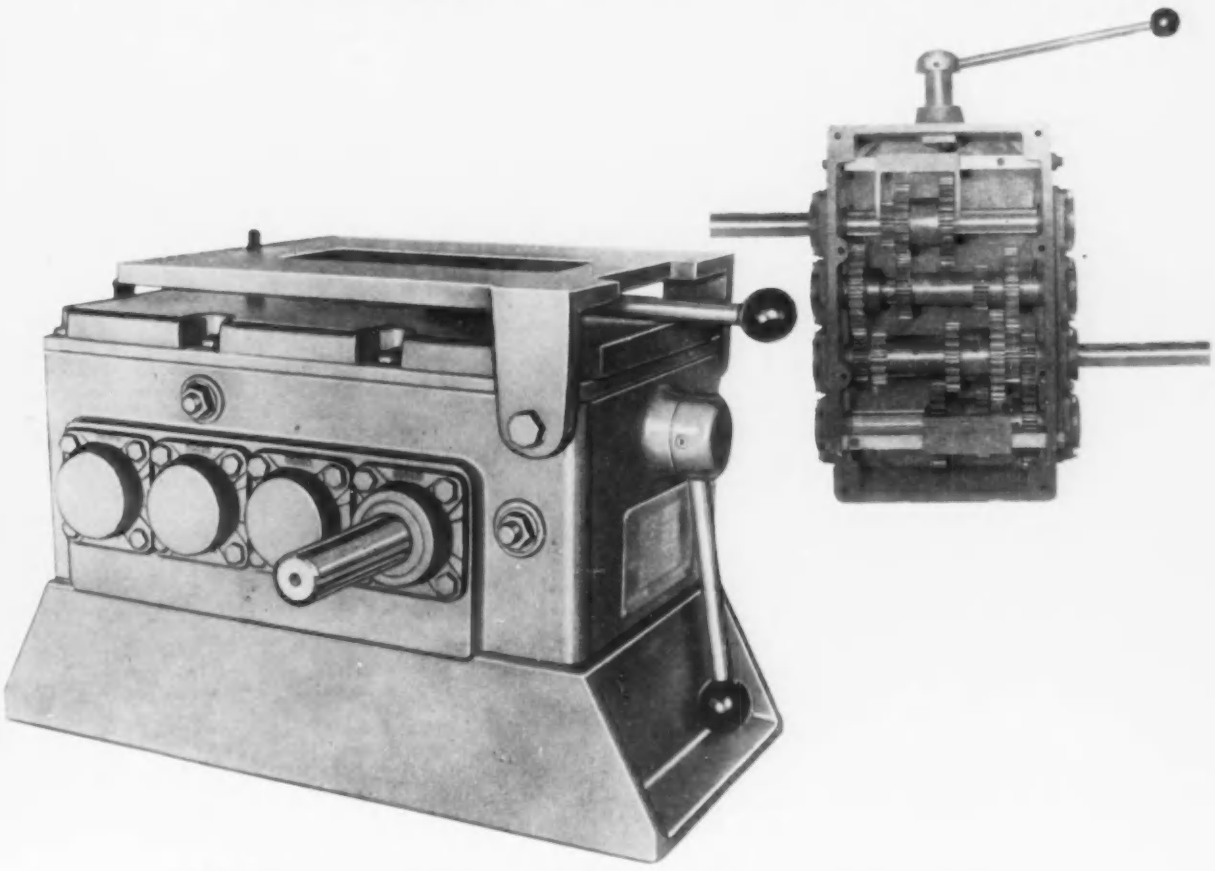
AMP INCORPORATED

GENERAL OFFICES:

5539 Eisenhower Blvd., Harrisburg, Pa.

Wholly Owned Subsidiaries: Aircraft-Marine Products of Canada Ltd., Toronto, Canada • Aircraft-Marine Products (Great Britain) Ltd., London, England • Societe AMP de France, Le Pre St. Gervais, Seine, France • AMP — Holland N. V. 's-Hertogenbosch, Holland
Distributor in Japan: Oriental Terminal Products Co., Ltd., Tokyo, Japan

NEW COMPONENTS and MATERIALS



Multiple-speed and Takeoff Transmission in Sizes up to 60 hp

These transmissions are available with gear arrangements to provide four, six, and nine ranges of speed. Standard high-to-low output ratios vary from 4.7:1 to 8:1, with max 12.4:1 step-down; a step-up ratio of 1:8 is possible in certain applications. Dimensions are 17 x 19 x 7 in. for Model 240, 20½ x 20 x 7½ in. for Model 540. Close-grained grey iron housings are used with 20°-stub tooth gears, and tapered roller bearings tested for overhung loads.

Such selective gear transmissions permit electric motors or gas engines to operate at their most efficient speeds, with no overload conditions. Smaller, high-speed electric motors may often be used instead of low-speed, more expensive types, it is also reported.

A variety of accessory mounts are available. In the mount having an attached rigid base, a top-hinged motor plate allows belt adjustment; in another with H-beam base, transmission and motor are mounted horizontally, and motor rails allow for belt takeup. Output shafts can be left or right-hand, forward, rear, or center-mounted, depending on gear train arrangement.

Standard units are designed for 1 to 60-hp capacities. Applications are expected on road machinery, textile machinery, machine tools, metal production. Various mounting accessories are available, for both transmission and motor. Price range is $245-390; delivery 10 days. **Turner Uni-Drive Co., 3429 Terrace St., Kansas City 8, Mo.**

Circle 1, inside back cover

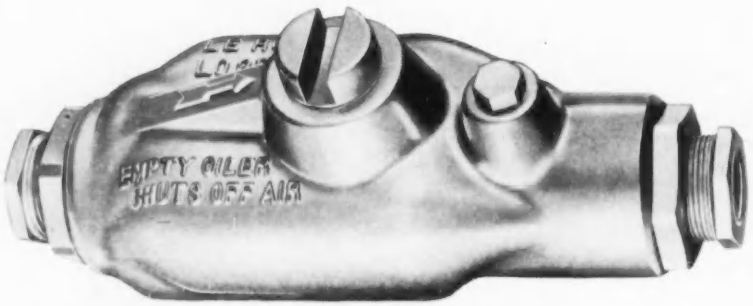
Glass and Quartz-reinforced Teflon for Insulation

Glass fiber-reinforced and quartz fiber-reinforced Teflon are expected to find use as electrical and electronic insulation. Because of their structure, these materials are said to have excellent machinability,

CONTINUED ON PAGE 126

outstanding dimensional stability over a wide range of temperatures, lower coefficient of expansion and reduction in cold flow compared with Teflon, and excellent electrical properties. These two materials are available in sheets, 16 x 21 in., with 1 or 2-oz copper on one or two sides, for etched circuits and terminal boards. Thicknesses, 0.031 to 0.375 in. Punched, machined or molded parts are also available. Price ranges: glass-reinforced sheets—$12-$140, quartz-reinforced—$14-$150, depending on the thickness; experimental quantities are available. **Rogers Corp., Rogers, Conn.**

Circle 2, inside back cover



Differential Pressures Operate Automatic Air Line Oiler

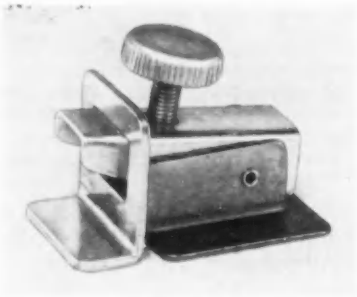
This oiler shuts off air supply when its oil is used up. The oil pickup feeds oil as soon as drilling starts; the moment the oil supply is exhausted, air supply to the air tool is shut off automatically. Capacity of 1 pt is said to be more than adequate for operating one shift.

The oiler can be refilled while in operation, eliminating interruptions. And oil flow can be adjusted without shutting off air pressure.

Differential pressures operate the automatic line oiler. Air is routed to create a pressure on the inside of an oil-resistant bellows; this forces a regulated amount of oil through a port, injecting oil into the air stream at the outlet end of the oiler. When the oil chamber is empty, the bellows activates the shut-off plunger, cutting off air supply to the air tool.

The oiler is aluminum and weighs 9 lb. Less than 1 ft long, it can be incorporated into air lines or mounted on compressors. Capacity is 300 cfm max. Price is $59.50; delivery is from stock. **Le Roi Division, Westinghouse Air Brake Co., Milwaukee 1.**

Circle 3, inside back cover



Compression fastener . . .

for any airtight, lightproof or vibration-resistant application. The cadmium-plated unit consists of a sliding, pivoted latch that is tightened down under a thumb screw. About 30¢ each, depending on quantity. **Dept. KP, Torit Mfg. Co., Walnut & Exchange Sts., St. Paul, Minn.**

Circle 4, inside back cover

Oil-submerged motor operator . . .

controls dampers in heating, ventilating air conditioning systems, and other industrial applications. The spring return, proportional-type unit features a new gear train and drive, completely submerged in oil and sealed in a die-cast case. Motor may be mounted in any position. Available in 24, 115, 208, 230 v. Optional accessories

for use with the standard assembly are: two or four-section switch kit for control of auxiliary circuits, potentiometer kit for use on self-balancing ac bridge applications and a rear shaft kit. **Barber-Colman Co., 1300 Rock St., Rockford, Ill.**

Circle 5, inside back cover

High-strength lock washer . . .

for heavy-duty applications has locking teeth and rigidity, is resilient under extreme loads. The washer for a ⅜-in. bolt will withstand torque of 500 in.-lb. Four-sided and six-sided pyramidal washers are offered in several sizes. They can be preassembled onto screws to eliminate hand assembly. **Shakeproof Div., Illinois Tool Works, St. Charles Rd., Elgin, Ill.**

Circle 6, inside back cover

Subminiature pressure snubbers . . .

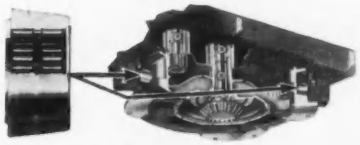
for high pressures and temperatures are stainless steel. Snubbers damp out high pressure surges and pump ripples, permitting a smooth-curve pressure increase. They protect gages, pressure transmitters, pressure switches, pilot valves and other fluid-pressure-operated instruments and control. Measures 11/16 in. x 1 1/16 in. Weighs 0.037 lb in ¼-in. line size. Designed for systems with operating pressures to 4000 psi; proof pressure to 6000 psi; burst pressure of 10,000 psi. Will operate

CONTINUED ON PAGE 128

BEARING TIPS by McGill

GUIDEROL® bearings add efficiency – and sealing – to greater capacity

for THEW LORAIN

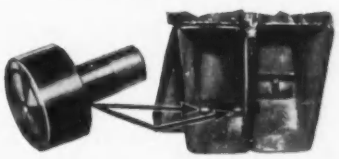


Special GUIDEROL® bearings for turntable rollers

Four of these specially designed turntable rollers support the entire weight of the superstructure plus overhanging work load. They replaced inadequate plain friction rollers to allow for smoother handling of even greater imposed loads with no track wear. Simplified lubrication and longer life reduced maintenance.

Sealed GUIDEROL® bearings for boom peak sheave

The integral seal design of these extra capacity bearings offers exceptional compactness in the Jib and Boom Peak sheaves. Unit costs are lower because counterboring for separate closures are unnecessary. Retained grease in the protected bearings eliminates climbing or lowering the boom for frequent relubrication.



Sealed CAMROL® Cam Followers for outrigger support

Located in the outrigger carrier channels, these cam follower bearings facilitate extending the supporting outriggers. Subject to heavy working loads, these sealed bearings provide low cost and dependable anti-friction support rollers that stay clean and well lubricated.

McGill bearings have the proven quality, design advantages, extra capacity and precision required to insure the efficiency of needle type roller bearings in all modern machinery. They are specified by Thew Lorain to help make the performance of their giant 75 ton Moto-Crane smooth, rugged and reliable under severe operating conditions. Thew Lorain specifies McGILL bearings in all heavy duty equipment for their outstanding dependability with reduced maintenance. McGill bearings will work equally well for you. Write for Catalog No. 52-A.

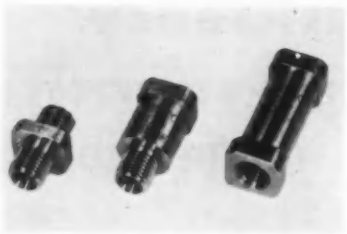
Sealed GUIDEROL® bearings for fairlead sheave

Fairlead sheaves at the base of the boom on drag lines and back hoes, etc. need bearings protected from contamination. Effective sealing against ever present dirt and grit materially extends bearing life.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA



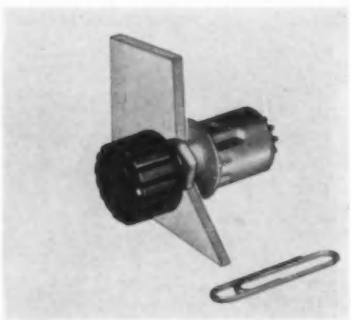
at fluid and ambient temperatures from —65 to 400 F. **A. U. Stone & Co., Inc., 23 W. 60th St., New York 23.**

Circle 7, inside back cover

Vibration-monitoring system . . .

for rotating and reciprocating equipment in hazardous locations, Class I, Group D and Class II, Groups F and G. Both the malfunction detector and control units are mounted in explosionproof casings. Control unit is used to provide a time delay when protected equipment is started, providing an alarm or shutdown from single shocks or transient disturbances. No vacuum tubes are used. Manual, electrical or automatic resets are available. Ac or dc. **Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. 4th St., Philadelphia 33.**

Circle 8, inside back cover



Multi-purpose miniature switch . . .

is a ten-position unit mechanically operative from 122 to 302 F, rated at 3 amp, 115 v, that withstands vibrations of 5 to 2000 cps. Has hermetically-sealed terminals and base and is immersion-tested and salt-resistant. It lends itself to explosion-proof applications. Insulation resistance is 100,000 megohm. Features hardened ball-bearing detents, molybdenum contacts and solid, coined silver contact arms. Switch is 1⅜ in. long excluding terminals, has over-all dia of ⅜ in. May be ordered for panel or flange mounting or with a sealed mount. **Components Div., International Telephone and Telegraph Corp., 100 Kingsland Rd., Clifton, N. J.**

Circle 9, inside back cover

Snubber guards air gages . . .

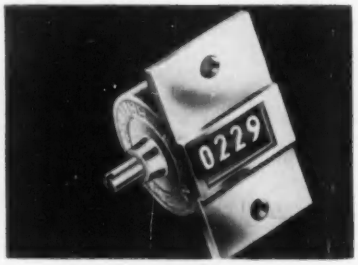
from sudden or variable air-line pressures. Has standard ¼-x ½-in. IPT fittings and is attached between the existing gage and the air-supply line. Until manually flexed in any direction for a pressure reading, all air pressure on the gage is shut off through an internal, fully housed valve assembly in the base fitting. A flexible neoprene body absorbs most shock. **Toolcraft Products Co., P. O. Box 92, S. Pasadena, Calif.**

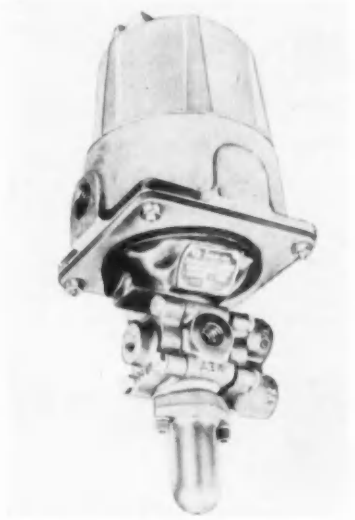
Circle 10, inside back cover

Non-reset counters . . .

permanently enclosed in a cylindrical case, are available in a range of three to six figures, 0.163-in. high in white on a black ground. Driveshaft is ⅛-in. dia and can project left or right. When additional actuation is necessary, it can project from both ends of the case. Revolutions may be counted at 1000 per min max, or count may be recorded at 1000 per min with a shaft input of 100 rpm. When driveshaft is connected directly to initial counting wheel, actuation is cushioned by a nylon shock-absorbing device. Two types of rachet action are available. Rachet components are nylon. Minimum arc required for stroke count is 36°; max counting rate is 500/min. All counters return to zero after max count has been reached. Case dia is 0.790 in. with mounting flanges at figure window or at bottom. **Technicraft, 6221 Ridge Ave., Philadelphia 28.**

Circle 11, inside back cover





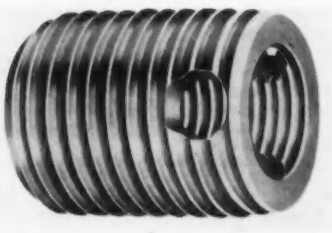
High-pressure valves . . .

with explosionproof enclosed solenoids are rated for oil and water pressures from 0 to 250, 0 to 1500, 0 to 3000 psi and air pressures from 0 to 250, 0 to 1000, 0 to 1500 psi. In four-way, three-way, shutoff and diverter flow patterns. Solenoids for 110, 220 and 440 v ac are standard. Valves feature a sealing ring in constant intimate contact with a mating slide. The sealing surfaces continue to lap themselves with each operation, maintaining their sealing qualities for millions of cycles. **Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58.**

Circle 12, inside back cover

Self-taping insert . . .

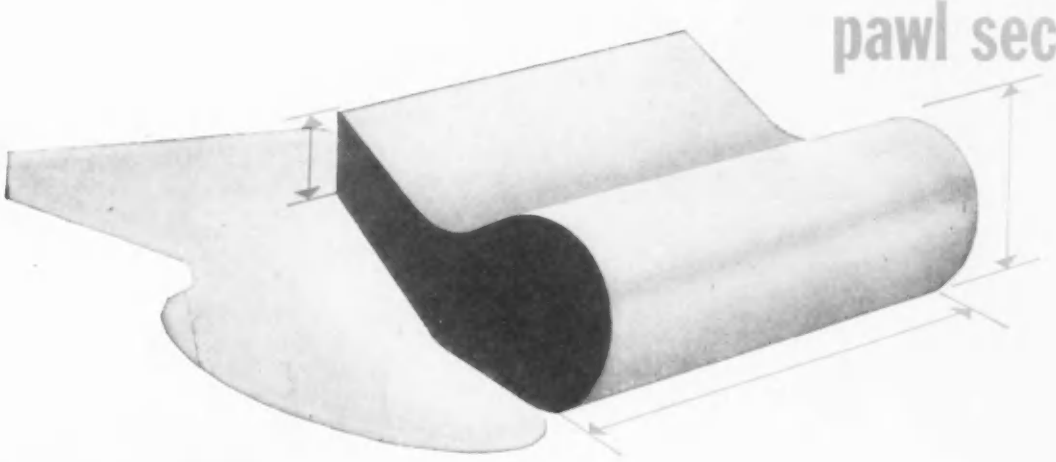
for driving into aluminum, magnesium and other structural materials accommodates standard threaded fasteners without

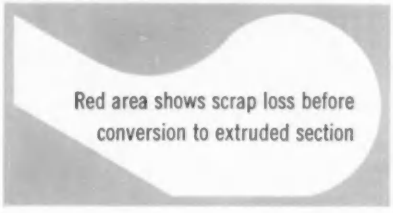


CONTINUED ON PAGE 130

52% saving

reported with J&L hot extruded cold drawn pawl section





This pawl was previously milled from a ¾" x 1½" hot rolled oil hardening tool steel. Conversion to a cold drawn extruded section cut cost from 45¢ to 22¢ per part.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 409, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin STEEL ... a great name in steel

TIPS ON USING RIVETS

A short design course guaranteed to save a lot of grief later on!

You could memorize these and thousands more design tips on the best use of rivets—but don't! Much simpler to call on Milford for the right answers to all your riveting design and application problems. Full-tubular, semi-tubular, split, cutlery, decorative—Milford makes them all from any metal that can be cold-formed, then adds a wide variety of platings and finishes.

To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

danger of stripping and withstands vibration without loosening. Pullout strength is limited only by the base material. Available in three standard lengths in case-hardened cadmium-plated or stainless steel. Three holes in the pilot provide balanced thread-cutting action; truncated external thread roots give 20% more wall thickness; internal threads the full length of the insert meet Class 2B or 3B specifications. **Groov-Pin Corp., Ridgefield, N. J.**

Circle 13, inside back cover

Primers for fusing vinyl to metal . . .

and nonmetallic surfaces include a white primer that forms a coating to withstand immersion in cold or boiling water and exposure to high humidity. Can be rolled, brushed, flow-coated or sprayed. A yellow bonding primer provides resistance to salt spray and salt water immersion. **Dennis Chemical Co., 2701 Papin St., St. Louis, Mo.**

Circle 14, inside back cover

Teflon-lined pipe, ells, tees . . .

are offered in 1 through 6-in. ID with flanged end-connections. Pipe comes in 10-ft lengths. Teflon lining extends over the entire raised face area of the flanges to make flat, smooth-mating surfaces. Tees have Teflon linings that are sold and weldless. Ells are available in long radius. Lining material will withstand pressures to 400 psi and temperatures from —90 F to 400 F. **John L. Dore Co., 5406 Schuler St., Houston.**

Circle 15, inside back cover

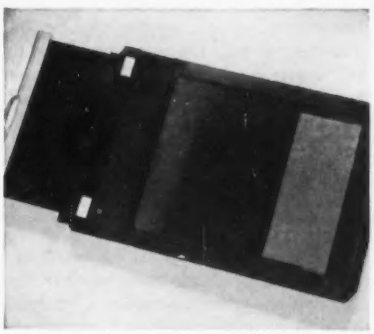
Blind fastener . . .

with threads that grip any kind of material from 0 to ⅜ in. thick, fastener is self-adjusting to grip evenly on rough and curved as well as smooth and level surfaces. Available in short lengths for thicknesses from 0 to 3/16 in., and long, for 0 to ⅜ in. Installs with a screwdriver and any US standard 6-32, 10-24, or ¼ in.-20 screw. Units make a vibrationproof assembly with weight-carrying capacity limited

(Continued on page 132)

take it in color

and you put Synthane laminated plastics to work



Slide for cut film holder—made from Synthane sheet because Synthane is opaque to infra-red rays.

At first glance the connection between color photography and Synthane laminated plastics may seem obscure. Actually, Synthane has long been at home in the manufacture and processing of film and in the developing of the finished picture.

Many types of rolls, loop sticks, and structural parts made of Synthane are used by the film manufacturer. Racks, film sprockets, reels and rollers employ Synthane in developing processes. In the infancy of color pictures (and ever since), racks and reels made of Synthane proved to be exactly what were needed to resist developing solutions, prevent film fogging through contamination. Film holder slides and various parts for cameras are other uses of Synthane in photography.

The photographic industry needs Synthane for its unique combination of properties. Resistance to moisture and chemicals, non-fogging qualities, its hard, smooth surface are all important characteristics. Synthane is tough, light in weight (half the weight of aluminum) and easily machined. These and many other chemical, electrical and mechanical properties make Synthane valuable throughout the length and breadth of industry.

Over 30 grades in sheet, rod or tube form or completely fabricated by us are looking for work with you. Write for information.

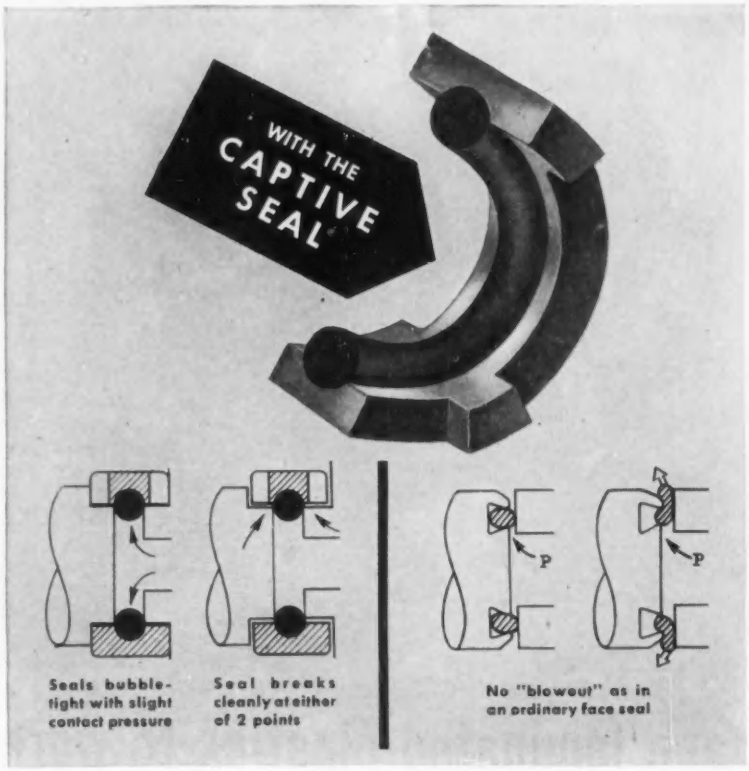
CHEMICAL RESISTANCE LIGHT WEIGHT

EASILY MACHINED MECHANICAL STRENGTH

SYNTHANE . . . industry's unseen essential

SYNTHANE CORPORATION, 4 RIVER ROAD, OAKS, PA.

Read the inside story of these **NEW** Aircraft Valves


WITH THE CAPTIVE SEAL
P
P
Seals bubble-tight with slight contact pressure
Seal breaks cleanly at either of 2 points
No "blowout" as in an ordinary face seal

Bridgeport, well-known supplier of aircraft bellows and assemblies, brings you a new sealing principle—the BERGEN CAPTIVE SEAL—and 3 new compact, light-weight valves.

Here is a seal that can't "blow out" because of its steel captor retainer that provides not one, but *two*, breaking points that instantly release pressure unbalance when the seal is broken.

The CAPTIVE SEAL itself does not wear, is not damaged by particles in the fluid stream. And anyone in the field can replace it.

General purpose Solenoid valve. ¼", 3way, 24 V.D.C., 3000 psi. Hydraulic—pneumatic.

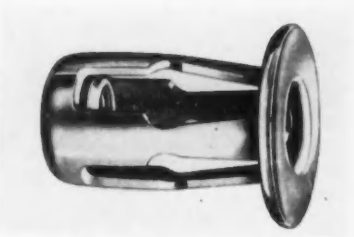
Screw socket Solenoid Pilot valve. 3 way, 3000 psi. Pneumatic.

General purpose Solenoid valve. ½", 3 way, 24 V.D.C, 3000 psi. Hydraulic—pneumatic.

Robertshaw-Fulton CONTROLS COMPANY

Write for new catalog containing complete operating and physical data on these and all other Bridgeport aircraft valves and products.

BRIDGEPORT THERMOSTAT DIVISION • MILFORD, CONN.



in most cases only by the strength of the material in which used. **Molly Corp., Reading, Penna.**

Circle 16, inside back cover

Self-locking nut . . .

is up to 58% lighter than the series it replaces. The miniature, right-angle, floating-anchor nut is produced in carbon steel, cadmium-plated, with a 55-F limitation, and in corrosion-resistant steel, for high-temperature or nonmagnetic applications. The distance from the mounting surface to the centerline and over-all width have been decreased. Rivet holes are maintained at standard 3/32 dia. **Kaynar Co., Kaylock Div., 820 E. 16th St., Los Angeles 21.**

Circle 17, inside back cover

Electrical insulation tubing . . .

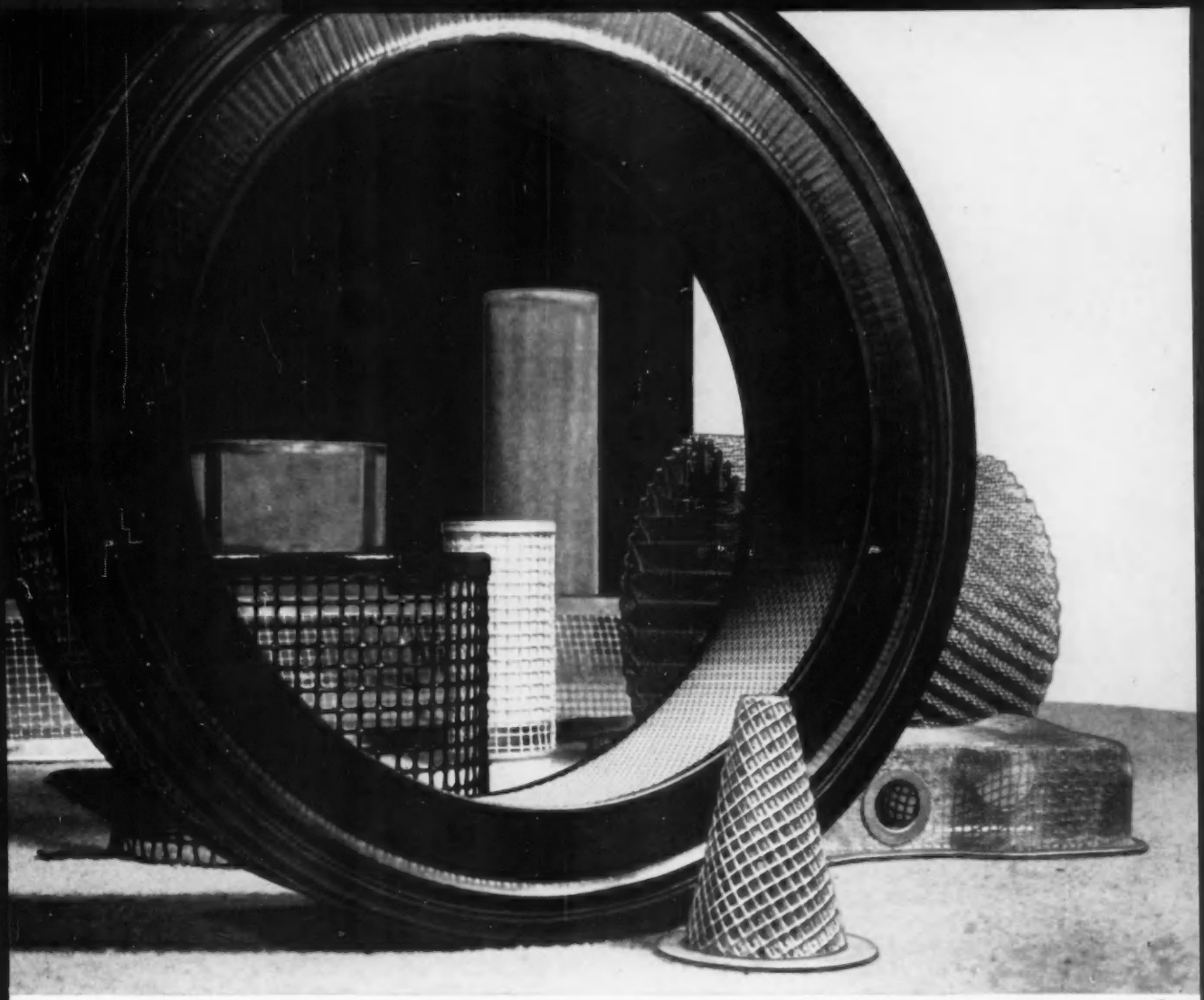
can be bent to twice its dia without cracking the coating. Made from braided glass fibers with a patented anti-fray treatment. Tubing is impregnated and completely coated with unmodified silicone varnish. Available in standard NEMA sizes in black and nine colors. **Bentley, Harris Mfg. Co., Conshohocken, Penna.**

Circle 18, inside back cover

Copper-clad Teflon sheet and tape . . .

for use in printed circuits. Has low dielectric constant, dissipation factor and water absorption. It is said to assure a uniform dielectric constant over a given area with no delamination. Available in 18 x 36-in.

(Continued on page 135)



How to **USE** wire cloth at lower cost

Today many companies are able to make wire cloth components, like these shown here, at lower cost than ever. The answer lies in new services, new developments worked out by the *Reynolds Wire Division* of National-Standard . . . ideas aimed at the more effective, less wasteful *use* of industrial wire cloth. For example . . .

5 SUGGESTIONS:

1. Check on wire cloth rolls 2 to 8 times normal length . . . for 2 to 8 times as much production in a single run. Fewer shutdowns. Less handling.

2. Consider pre-slit widths, plain or with woven-in reinforcement, as narrow as 1 inch or less, to meet your requirements exactly with minimum handling and waste.

3. Evaluate Reynolds' new palletized packaging. Less chance of damage. Faster, easier handling on arrival, in and out of storage and right to production operations.

4. Look into the many different weaves, meshes, metals, finishes and coatings . . . some unique with Reynolds . . . to make sure of the optimum specification for your requirement.

5. By all means take advantage of Reynolds' engineering and analytical service . . . nation-wide and unmatched in the industry. Time and time again it contributes to a better finished product at lower cost.

NATIONAL NS NATIONAL-STANDARD Company **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; fine wire, stainless, music spring and plated wires • WORCESTER WIRE WORKS, Worcester, Mass.; music spring, stainless and plated wires, high and low carbon specialties
WAGNER LITHO MACHINERY, Secaucus, N. J.; metal decorating equipment • ATHENIA STEEL, Clifton, N. J.; flat, high carbon spring steels • REYNOLDS WIRE, Dixon, Ill.; industrial wire cloth

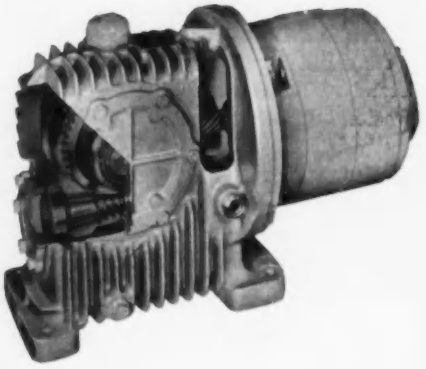
Here's a whole new family of fine GEARMOTORS by Cone-Drive Gears

MOUNT THEM ANYWHERE—FLOOR, WALL, CEILING, OR HANG THEM ON A SHAFT...

. . . there's a Cone-Drive gearmotor for every need. Look at the extensive line of space-saving, power-packed models now available. No matter whether you're faced with floor, wall, ceiling, or shaft mounting at any angle, Cone-Drive Gears has a gearmotor for the job.

It's the most versatile line available PLUS big power capacity in a really compact package. Double-enveloping worm gears, pioneered and proven by Cone-Drive Gears, are combined with a helical primary and extra-large taper roller bearings in a rugged finned housing to give you a power package without equal. You can select any model in any of 27 standard output speeds (7.3 to 525 rpm at 1750 rpm input) in capacities from 1 through 25 horsepower.

Best of all, Cone-Drive gearmotors are priced right down with units that can't deliver nearly as much performance and versatility. Check your nearby Cone-Drive representative or write today for new Catalog 57 containing complete specifications.



Cutaway view of typical Cone-Drive gearmotor illustrates use of double-reduction gear train for increased output power. Note also large taper roller bearings and heavy-ribbed housing.

CONE-DRIVE GEARS

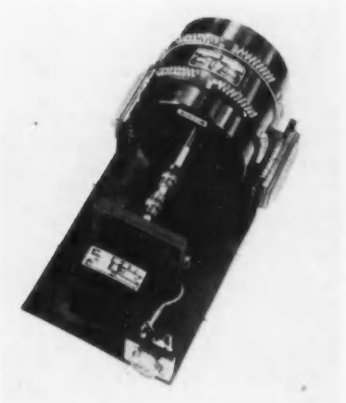
Division Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

7171 E. McNichols Road • Detroit 12, Michigan

sheets in 1/6 to 3/16-in. thicknesses, with 1 or 2-oz copper on both sides. Tapes range from 12-in. wide to 150-in. long with thicknesses from 0.005 to 0.060 in., with 1, 2 or 3-oz copper on one or two sides. **Fluorocarbon Products, Inc., div. U. S. Gasket Co., Camden 1, N. J.**

Circle 19, inside back cover



High-speed sampling switch . . . has miniature connectors attached to barrier strips on either side of switch. Typical applications include stabilization of groups of high-gain dc amplifiers, multichannel data systems, and error-indicating systems. Two poles, 120 contacts, 60 nonshorting channels per pole. Available with or without drive motor. Motor supplied with the switch operates on 115 v ac, 60 cps. Approximate dimensions, 5¼ x 5¾ x 10 in. **General Devices, Inc., P. O. Box 253, Princeton, N. J.**

Circle 20, inside back cover

Miniature ac motor . . . is rated 60 in.-oz at 1 rpm. Designed for high-speed controllers, counters and metering devices, the permanent-magnet mo-

(Continued on page 136)

Seal it tight with non-staining white . . .

PRESSTITE SEALERS

Recommended where sealer may partially show . . . as in refrigerator application above, where it is pumped between food liner and bottom breaker strip to prevent moisture and spillage from reaching insulation.

Presstite No. 422 Sealer:

1. Ideal for sealing between rubber-glass, rubber-metal, wood-metal, or metal-plastics surfaces.
2. Does not soften or stain plastic.
3. Has no contaminating odor nor delayed odor growth.
4. Will not support mildew.
5. Remains permanently soft.
6. Is non-corrosive, non-hygroscopic.
7. Will not stain enameled or painted surfaces.
8. Cold application makes it safe, neat, efficient.
9. Workable with knife or pump (beads as small as 1/16" diameter).

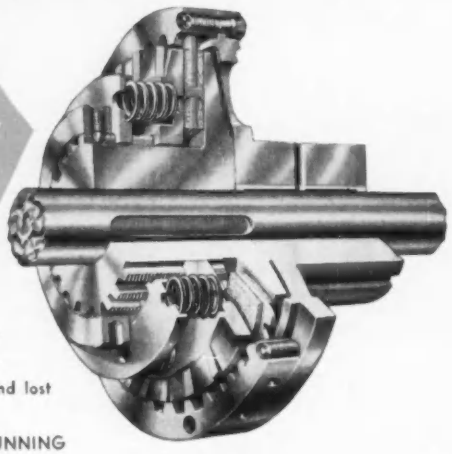
FREE . . . working sample and data on request.

PRESSTITE Sealing Compounds
PRESSTITE-KEYSTONE ENGINEERING PRODUCTS COMPANY
K A P

A Division of AMERICAN-MARIETTA COMPANY
3750 CHOUTEAU AVENUE, ST. LOUIS 10, MISSOURI

HILLIARD *Clutches*
FOR POWER CONTROL DESIGN

ADJUSTABLE *Slip Clutch*



- PROTECTS against overload, jams and down time.
- RESUMES THE DRIVE AUTOMATICALLY after overload.
- ELIMINATES SHEAR PINS and lost time.
- ADJUSTABLE - WHILE - RUNNING feature is available.

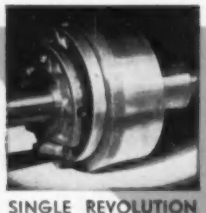
Hilliard Slip Clutches are continuously protecting the drive on dish washing machines—printing presses—packaging machines—case loaders—foundry equipment— air filters—conveyors—overhead doors—and many others.
They maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

The adjustable-while-running types are used to maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

WRITE TODAY FOR BULLETIN 300 WITH COMPLETE INFORMATION.

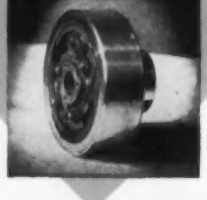
● OTHER HILLIARD CLUTCHES ●

CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS



SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.



OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet, or backstop action. Ask for Bulletin 231.

THE HILLIARD *Corporation*

MANUFACTURING CLUTCHES FOR OVER 50 YEARS

101 W. FOURTH ST. ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

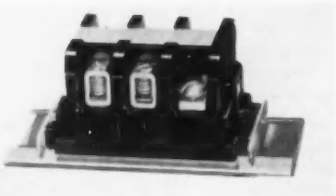
tor is offered in speeds from 72 to 2 rpm. Unit has input of 2.5 w, 1 5/16-in. depth, and 95 F max temperature rise. Provides instant stop in any position. Available in left or right rotation in all speeds. Operates on 250 v, 60 and 50 cps. **Cramer Controls Corp., Centerbrook, Conn.**

Circle 21, inside back cover

Explosionproof pressure control . . .

is calibrated to provide accurate control in hazardous locations. Pressure settings are made with an external adjustment knob and calibrated dial. Models are available with adjustable range spans between 0 and 500 psi and max pressures to 600 psi. Switch differentials in the 22 models range from 1.5 in Hg(±½ in.) to 7 psi, ±3. Can be supplied with any one of three standard snap-action switches. Suitable for 180-F ambient temperatures and are rated 15 amp, 115 or 230 v ac. **United Electric Controls Co., 79 School St., Watertown, Mass.**

Circle 22, inside back cover



Sectional terminal blocks . . .

may be assembled on the job without fastenings or may be factory preassembled to specifications. Tubular contacts for stripped wires, or combinations of two or more wires, are available with screw contact for No. 18 through No. 8; clamp contacts are available for No. 22 through No. 10 wire. Strap-screw contacts for terminal-ended or looped wires accommodate any 5/16-in. or narrower ring or spade terminal for No. 6 or larger stud. Rated at 750 v, the blocks are said to withstand voltages in access of AIEE requirements. Sections are 63/64-in. high x 1⅛-in. wide. **Huchanan Electrical Products Corp., Route 22, Hillside, N. J.**

Circle 23, inside back cover

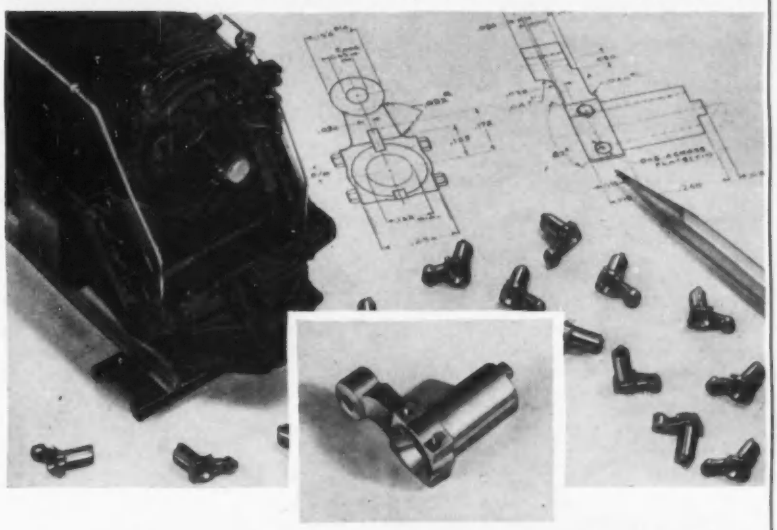
All-glass Y-type valve . . .

is virtually impervious to corrosion. Made of tempered borosilicate glass, the 2-in. valve is corrosion-resistant, stands less than 1-ft high, measures 10 in. face-to-face, and weighs 9 lb, including mounting bracket. Working parts exposed to fluid are glass or Teflon. Acidic fluids can be

(Continued on page 138)

GRC DIE CASTING HELPS LIONEL ACHIEVE TINY PART AUTHENTICITY

Tiny, intricate, too costly to make in their own plant, GRC's specialized techniques made this toy crank economically possible



While it would seem more advantageous for manufacturers to make all parts in their own plants, some have found that a specialist can do it cheaper, faster, and some times even better. This Lionel toy crank is an example. GRC specialized techniques made it possible for them to produce this tiny authentic part more quickly and more economically than Lionel could themselves. Die cast in zinc alloy in a single automatic operation, the cost of the GRC crank was little more than $5.00 per thousand in lots of 500,000.

Miniature in size, intricate in shape, the crank has, for example, four subminiature hex nuts measuring .045" across the flats. It is typical of the many small parts problems solved by GRC, who specializes in parts "no bigger than your thumbnail". It is typical too of the close tolerances, clean edges and great accuracy achieved by Gries' methods. Whether simple or complex, quality is uniform—no secondary operations, no scrap loss. GRC delivered parts are ready for immediate use.

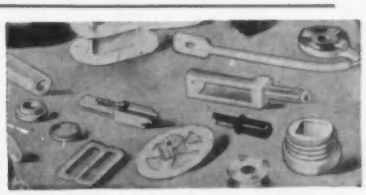
The world's foremost producer of small die castings, Gries' exclusive patented methods have resulted in many production economies and give broad flexibility in design. If you have a small parts problem, write for Gries' informative die casting bulletin or send prints for quotations. There is no minimum size; maximum, 1¾" long, ½ oz.

New Gries Bulletin Explains How Movable Multiple Part Units are Cast-Assembled by INTERCAST Method

The unique "intercast" method developed by Gries Reproducer Corporation for cast-assembling in one operation movable multiple part units, as well as continuously interlocked assemblies (such as chains), is explained in a new bulletin. Maximum size for "intercast" parts is 1½" long.

This patented automatic, time-saving, money-saving method is an ingenious refinement of Gries' exclusive method of small parts die casting. Gries' technique of both zinc alloy die casting and plastic molding of tiny parts is well known and has proved of inestimable value in overcoming design limitations and lowering costs. Automatic production assures precise tolerances and uniform quality.

Copies of the bulletin are available from Gries.



GRC Nylon and Other Plastic Molded Parts Accurate and Uniform

Unique, automatic molding techniques developed by Gries Reproducer Corp. permit mass production of nylon and other thermoplastic parts with exceptional accuracy and uniformity. Molding with single cavity techniques, GRC avoids lack of uniformity in size from cavity to cavity, difficulty in matching (flash and off-set at parting line), difficulty in filling. For the ultimate user it means no parts sorting to detect defectives, no selective assembly to compensate for variations, no cleaning operations.

Specializing in tiny parts (their maximum size is 1¼" long, .03 oz. in weight, no minimum), GRC can make quick deliveries on quantities from 50,000 to many millions, and will quote promptly upon receipt of blueprints or specifications. Samples and factual bulletin can be obtained by writing directly to Gries Reproducer Corp. in New Rochelle.

GRC High Series Cap Nuts Now Cataloged In Stock

Never before available to industry as a stock item from any supplier, GRC is now stocking for prompt delivery cap nuts with up to 50% greater thread depth. Immediate shipment can be made on a complete range of hex sizes from 7/16" to 5/8". Die cast in zinc alloy with long, clean thread sections, the overall height of the cap nut is well proportioned between the hexagonal section and the dome of the fastener. Protective, neat and attractive, they are rustproof, corrosion-resistant, nonferrous, without tool marks or cut-off burrs. They have a naturally bright finish and if required any standard finish can be applied. Other GRC stock fasteners include wing nuts and screws, round head thumb nuts and screws, standard cap nuts, rivets and others. Catalog and spec sheets on the new high series cap nuts and other fastenings are available on request.

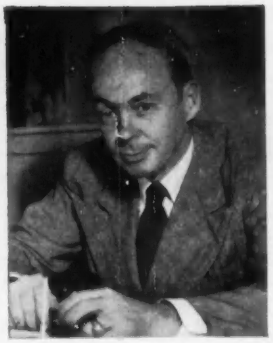
WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

GRIES

GRIES REPRODUCER CORP.

159 Beechwood Avenue, New Rochelle, N.Y. • New Rochelle 3-8600

MICRO-BEARING ABSTRACTS



by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

BEARING FITS AND FITTING PRACTICES

As shown in *Fig. 1*, the fitting of Micro-Bearings, like the fitting of larger ball bearings, chiefly involves the clearances between the inside diameter of the housing and the outside diameter of the bearing; the bore of the bearing and the shaft diameter.

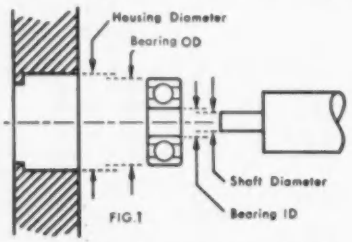


FIG.1

The achievement of the desired fit by dimensioning is illustrated in *Fig. 2*. The bearing ID is represented by the top blocks and the shaft OD is represented by the lower blocks. Such a block diagram could also be applied to housings and bearing outside diameters. In this block diagram, it will be noted, the bearing ID is represented by a .00015 tolerance with a similar tolerance for the shaft. A resulting fit of line to line to .0003 loose is shown.

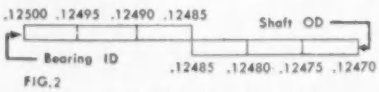


FIG.2

An interference fit not tighter than line to line is suggested for the following reasons:

1. *Difficulty in assembly.*
2. *Difficulty in disassembly. This is often more hazardous than the assembly operation and may result in total bearing destruction.*
3. *Reduction in radial play.*
4. *Danger of bearing ring conforming to possible poor geometry of mating shaft or housing.*

TOLERANCE DISTRIBUTION

The maximum .0003 loose condition shown in *Fig. 2* may be excessive in some applications. The fitting problem then resolves itself to reducing this extreme, and yet maintain the maximum tight fit of line to line. The looseness may be reduced by redimensioning the shaft to .12490/.12475 as shown in the block diagram, *Fig. 3*.

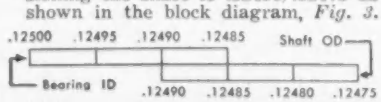


FIG.3

If the frequency distributions of shaft and bearing ID sizes were statistically normal, the modal fit of all parts would be 0.0001 loose. Accordingly, an insignificant percentage of parts would be mated to the extreme values, and for practical purposes could be ignored.

With regard to bearings' outside diameters and bores, however, normality of the distribution curve cannot be assumed. During the grinding operation, the "most metal tendency" tends to skew the frequency distributions for bearing ID's and OD's in the direction of most metal.

In grinding and finishing shafts and housings, similarly skewed distributions occur.

Operating on a modified probability distribution of tolerance is possible if the volume of parts is sizeable. But the approximate distribution of shaft and housing sizes must be verified if this method is to be used.

MATERIALS and SURFACE FINISHES

The ease of assembly is also affected by materials and finishes. The following factors must be considered:

1. *The galling characteristics, hardness and ductility of the materials involved.*
2. *Finish lay patterns produced by various tools and techniques used.*
3. *R M S surface finish values achieved.*
4. *Geometry of shafts and housings as regards out-of-roundness, taper, etc.*

The possible combinations of these elements in any single application are so numerous that their gross effect can only be ascertained by trial and error, or by a detailed study of operations on individual applications. A more complete discussion of fitting practices, including sizing methods and coding, is found in our design handbook.

DESIGNERS HANDBOOK FREE TO ENGINEERS

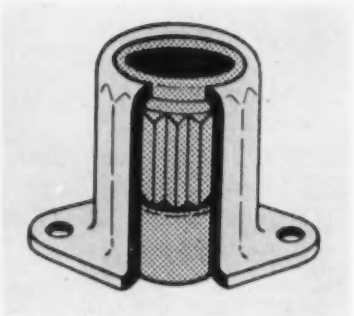
If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

It will be sent free to engineers, draftsmen and purchasing agents. Write to:

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

handled to 250 F. Low thermal expansion allows a sudden temperature differential of as much as 200 F through the valve. Max line pressure is 50 psi. Spring-loaded stem keeps the plug tight when closed and holds it in any position until the handwheel is turned. Travel depth of the 2-in. glass plug, raised and lowered by a nonrising stem is 2⅜ in. Valve body is armored with a fiber glass polyester resin sleeve. Can be mounted in any position. **Corning Glass Works, Corning, N. Y.**

Circle 24, inside back cover



Universal shim-nuts . . . are said to eliminate weight and assembly costs in applications formerly requiring stacked shims under nuts. Different heights are coded by color. Units have serrated aluminum housing, tubular spacer and stop nut or all-metal lock nut. Spacer is press-fit into the holder after the nut has been inserted, making a single unit. **William H. Snow Co., 1413 E. Franklin Ave., El Segundo, Calif.**

Circle 25, inside back cover

Bearing temperature indicator . . . anticipates failures in rotating machinery by detecting acceleration of temperature rise. Calibrated to indicate temperature change of 150 F when using an iron-constant thermocouple input. Operates on 115 v ac, ±10%, 60 cps, uses 21 w. Instrument consists of thermocouple input balancing circuit, high-gain amplifier, rectifying and metering circuit, differentiating

(Continued on page 142)

Formica helps solve rocket thermal insulation problems

New Formica laminated plastic thermo-insulator provides protection from hot launching gases

In cooperation with Rocket Fuels Division, Phillips Petroleum Company, Formica application engineering applied Grade FF-34 (modified) with the precise characteristics for protection against hot gases.

This Formica fabricated liner protects the steel blast tube through a time cycle of intense heat in a new target drone.

This solution called for three of the Formica-4 services that assure the right laminated plastic for every requirement.

1. Application engineering to select the right grade
2. Research to adapt it to this particular application
3. Fabricating to produce a complete component ready for assembly. A fourth—Customer Stock Service—provides a ready supply of sheets and rods for prompt shipment.

This unique laminated plastics service can be of assistance to you in your own product design problems. For complete information, send for free Formica-4 bulletin 584. Formica Corporation, a subsidiary of American Cyanamid, 4516-7 Spring Grove Ave., Cincinnati 32, Ohio.

Save your engineers' time . . . use Formica-4, the complete laminated plastics service

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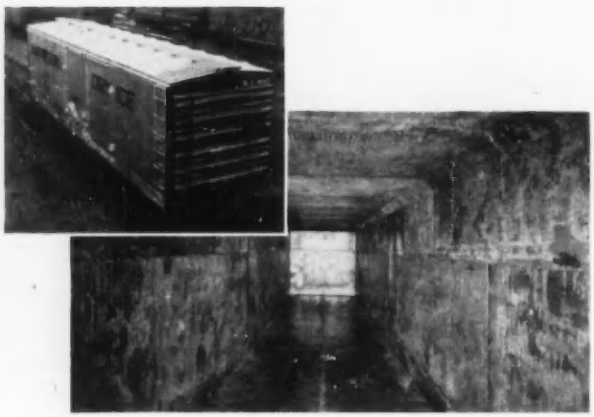
FI-1586

OLIN MATHIESON'S SWITCH TO RUBATEX GAVE THEM $50 SAVINGS PER DAY

"Our old dry ice rail cars, insulated with other low temperature insulations lost as much as 2% of net load per day. New cars insulated with Rubatex have an established daily loss of under ½ of 1%—a saving of salable dry ice at destination for every day under load of $50 compared with former insulation. This lower evaporation loss has been maintained because of the greatly decreased water pick-up of the Rubatex as insulation."

D. F. McCauley, Sales Engineer
Olin Mathieson Chemical Corporation
Baltimore, Maryland



Modern LRC type car, considered the largest and most efficient in the industry. Built by Fruit Growers Express Company to the design and under supervision of Olin Mathieson. Cars are metal lined, welded, backed up with T&G wood. No load members buried within the insulation to support the ice; total load of 53 tons is carried by the Rubatex Insulation itself. Back of the wood inner lining (in turn capped by welded galvanized metal) is solid Rubatex. Rubatex floor thicknesses are 10"; side wall 14"; roof 8"; car ends 12". Thicknesses made up of 3" and 2" sheets of Rubatex.

Basically same car design, with modifications required by weight restrictions, is used in Olin Mathieson's dry ice delivery trucks and trailers. Using so-called 'floating floor'—meaning no use of load members other than Rubatex Insulation itself—minimizes heat entry to what is considered to be lowest possible.

Rubatex Insulation Hardboard has met the exacting requirements of Olin Mathieson's low temperature insulation specifications for ten years. Here's an insulation, unlike other materials, which is completely self-supporting with an average load-bearing compressive strength of 60 lbs. per square inch yet is surprisingly light in weight—only 4.5 lbs. per cubic foot. In addition, Rubatex has the lowest heat conductivity of any known structural material, K-factor 0.21, and its closed cellular structure cannot absorb moisture even at cut edges.

Whether you design or specify insulation for rail, truck, or trailer equipment—check the cost saving advantages of Rubatex in the over-all construction of the job—plus its longer and more positive efficiency compared to other insulating materials.

RUBATEX DIVISION, Dept. P-9
GREAT AMERICAN INDUSTRIES, INC.
Bedford, Virginia

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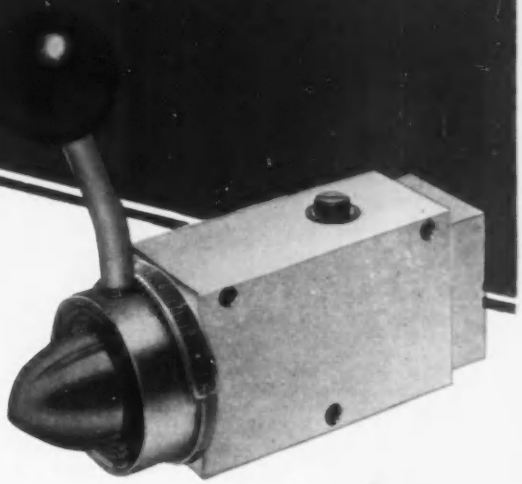


CONSULT WATERMAN

Waterman controls are known for their accuracy, dependability, safety, and low maintenance cost.

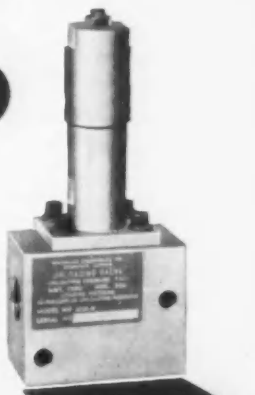
Adjustable Flow Regulators range from 0.5 GPM to 20 GPM. They maintain a constant rate of flow regardless of resistance or pressure fluctuations.

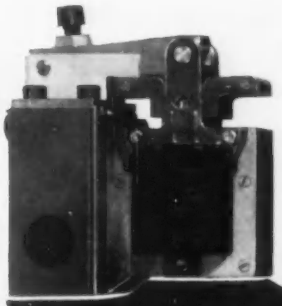
No. 1 Check Valves are one piece, Nylon Poppet, aluminum body and low pressure drop.

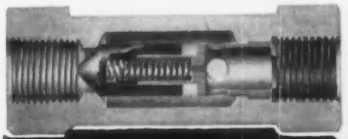
No. 2 Micronic Line Filters have operating pressures to 3000 psi, 40 micron filtration, replaceable elements, and are available in ⅜" and ¾" NPT.

No. 3 Solenoid Valves are inexpensive, compactly built units for hydraulic systems handling non-corrosive fluids. Capable of continuous operation for working pressure to 3000 psi.

No. 4 Unloading Valves for pressures to 3000 psi. Flow rates to 30 GPM. Fast acting, maintain desired pressure without continuous readjustments.







Send for Bulletin E

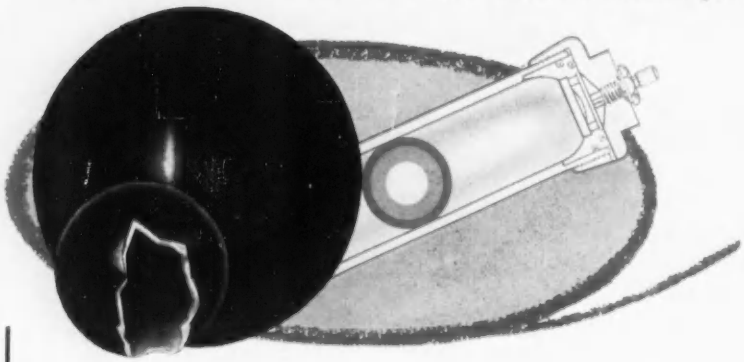
Write for data on any of these WATERMAN products

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE — EVANSTON, ILLINOIS

THE SHAPE OF THINGS IN MOLDED RUBBER

RUBBER GETS ON THE BALL VIA "APCOTITE" BONDING AND MOLDING TECHNIQUE



APPLICATION:

The rubber covered aluminum ball shown here is a piston in a hydraulic accumulator of revolutionary design. Advantages of a ball type piston are many. Being spherical and free rolling, no one point takes the wear, and it permits the accumulator to be operated in a horizontal position. Molded slightly larger than the cylinder in which it operates, it creates a perfect seal. The entire system and accumulator were designed and patented by a famous New England engineering firm.

PROBLEM:

Pressure within the cylinder caused the rubber on the sphere to flow and pull away from the aluminum surface of the ball. Customer asked Acushnet to produce a better bond and covering.

SOLUTION:

Acushnet engineers and lab chemists voted not to use pins or location rods of any kind to hold the ball in place while molding but elected to use a preforming mold prior to curing. The final curing of the rubber covering included the use of "APCOTITE," an exclusive Acushnet rubber-to-metal bond. The cross section shown here is proof that a uniform layer of rubber concentrically perfect was obtained on the aluminum insert.

Apcotite bonding to metal is exclusive with Acushnet and provides for high strength bond of rubber, synthetic polymers, silicone and plastics to all metals for the life of the part. Technical assistance at any stage of design is available from the Acushnet laboratories. Send for brochure describing Apcotite bonding in detail. Specify "APCOTITE"!

Acushnet

ACUSHNET PROCESS COMPANY

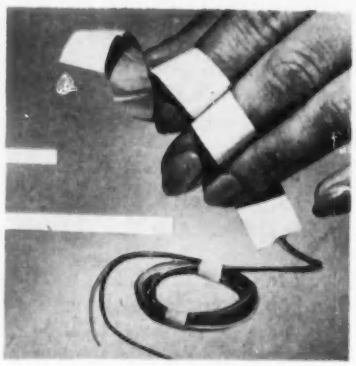
NEW BEDFORD, MASSACHUSETTS

... *Precision Molded* **RUBBER, SILICONES - "APCOTITE" BONDING**

Address all communications to 768 Belleville Ave., New Bedford, Mass.

network, a thyratron control circuit and a power supply. **Lycoming Div., Avco Mfg. Corp., 550 S. Main St., Stratford, Conn.**

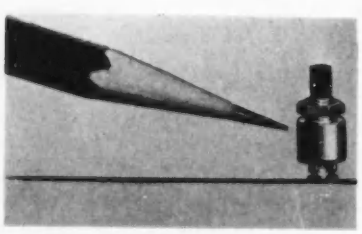
Circle 26, inside back cover



Temperature-indicating ribbon . . .

encloses a resistance element of nickel-alloy wire. Less than 0.020 in. thick, the flexible ribbon may be cemented to flat, cylindrical or irregular surfaces. Self-adhering ribbon is also available. Designed to operate over wide temperature ranges, at high altitudes and under severe physical conditions. Made in several shapes and sizes. **Minco Products, Inc., 740 Washington Ave. N., Minneapolis 1.**

Circle 27, inside back cover



Pushbutton switch . . .

measures 0.250 in. dia, has over-all length of 0.615 in., with 0.315 in. behind the panel, including soldering terminals. Designed for use with 1/16-in. panels and requires a 3/16-in. hole for mounting. Switch is SPST, momentary-contact, nor-

(Continued on page 146)

PYRAMIDING DESIGN TALENT

Thin sections, holes, bosses, metal savers, odd shapes all produced in a split second—from molten metal. No other process can compete with this for eye appeal or low cost.

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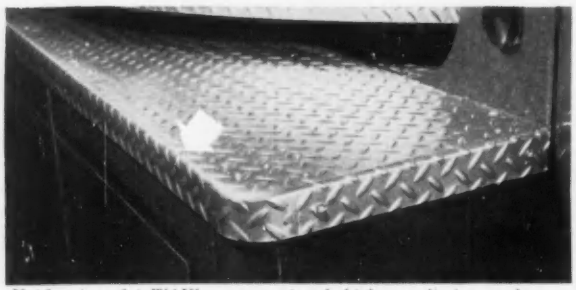
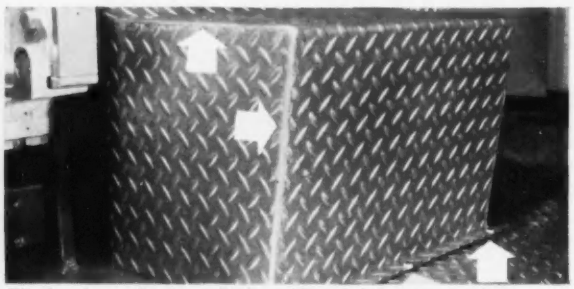
tough fabricating job on fire engine proves 4-WAY'S® versatility

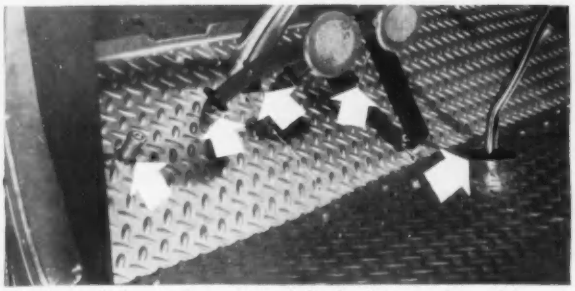
Fabrication to form even the varied and complex shapes used on firefighting equipment is no problem with 4-WAY Safety Plates. No special tooling is necessary. Ordinary cutting, drilling, forming and similar standard shop equipment is all that's needed. Good reason why this leading chassis and body manufacturer has specified Inland 4-WAY for more than 15 years! 4-WAY is used in an uncommonly wide variety of ordinary and extraordinary applications. For complete information and specifications, write Dick Prendergast, Room 1262 at the address below.



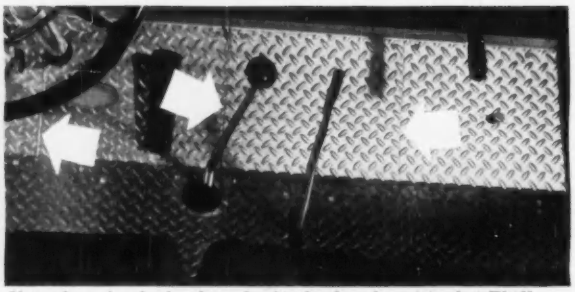
Uniformity of 4-WAY's cross-sectional thickness eliminates the possibility of deflection while bending, even at sharpest angles. Standard equipment can be used.



Whether the application calls for welding, bolting, or screw fastening, all are easily accomplished on 4-WAY with conventional methods.



Punching, drilling or flame cutting holes for fasteners, foot pedals, etc. is no problem with 4-WAY.



Notice how cleanly the plates for this floorboard are joined. 4-WAY can be sheared to extremely close tolerances eliminating all guesswork and make-overs.

Inland 4-WAY® Safety Plate

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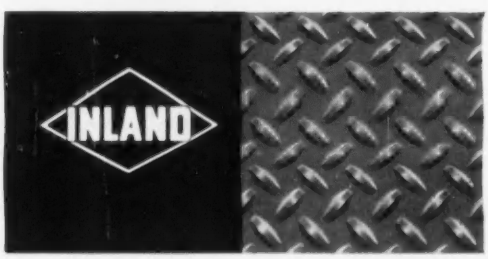

WEBSTER'S NEW PILOT OPERATED RELIEF VALVE

Compact design adapts to "tight" installations. Adjustable from 500 to 2000 psi. Maximum capacity, 20 gpm.

BOOSTS WORK OUTPUT 38.5%!

call the man from Webster

His intimate knowledge of this new relief valve — its many benefits and applications — can help in adapting it to your product.

Full speed power up to 93% of relief setting is now possible with this new Webster pilot operated relief valve. Result: 38.5% work bonus over "brute-force" type valves! More, you get all the benefits of clog-free performance, quieter operation...lower price. Mighty sound reasons for specifying Webster's pilot operated relief valve *now*.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC
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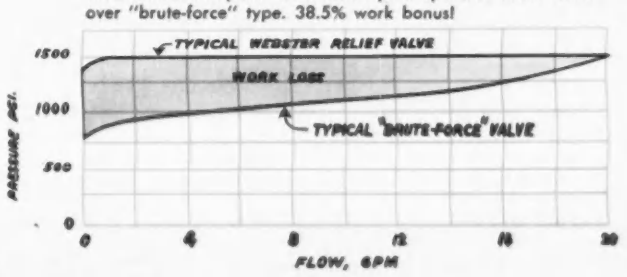
Typical performance curve shows minimum pressure drop and instantaneous response of Webster pilot operated relief valve over "brute-force" type. 38.5% work bonus!



- ☐ *Have THE MAN FROM WEBSTER contact us—*
  —Please send the following:
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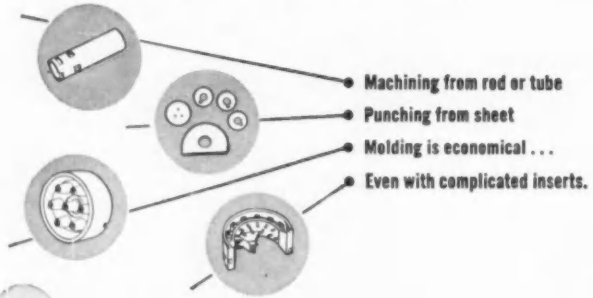
franklin adv. H104

Looks complicated, but this connector strip was actually produced by a few simple machining operations on standard Ace hard rubber rod. The design engineers chose an Ace compound that not only has excellent strength (up to 10,000 psi), excellent surface resistance and top insulating properties, but also is free-machining. A few high-speed milling and drilling operations, then soften by heating, press in the metal inserts, assemble the contacts with screws, and the job's done. An amazing variety of shapes and compounds of Ace Hard Rubber are possible, even extruded directly over metal rods or tubes. Stir your imagination? Write for more facts today.

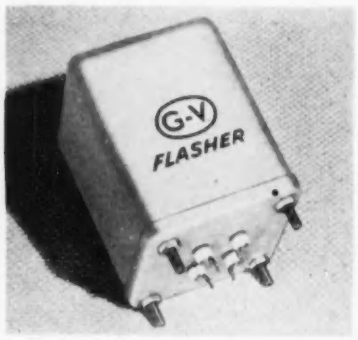


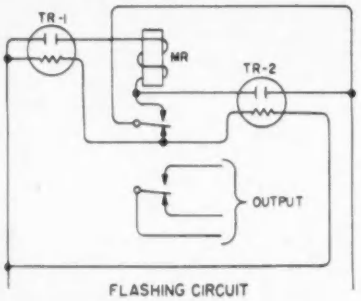
ACE rubber and plastic products

AMERICAN HARD RUBBER COMPANY
DIVISION OF AMERACE CORPORATION
ACE ROAD • BUTLER, NEW JERSEY

mally-open model, rated 1/10 amp at 115 v ac resistive. Life expectancy is 200,000 min at rated load. **Grayhill, Inc., 561 Hillgrove Ave., La Grange, Ill.**

Circle 28, inside back cover





FLASHING CIRCUIT

Heavy-duty flasher . . .

for long life with loads to 2 amp, 120 v ac or 32 v dc. Combines two thermal relays and a magnetic relay, hermetically sealed, in a circuit in which the load current is handled by the magnetic relay. Thermal relays govern on and off portions of flushing cycle. Compensated for ambient temperatures from —85 F to 257 F. Can withstand aircraft vibration and shock requirements. Contained in a case 2 9/16 x 2 9/16 x 3 3/16 in. and weighs 9 oz. Output contacts are SPDT and are isolated from input circuit. Standard units are offered for 26.5-v-dc and 115-v-ac energization and for 20, 60 and 90 flashes per min. **G-V Controls, Inc., Hollywood Plaza, East Orange, N. J.**

Circle 29, inside back cover

High-torque differential . . .

has double-pinion, hollow-shaft construction. AGMA precision Class II gearing is used in conjunction with shielded ball bearings. Backlash at no load is under 1 min, with starting and running-friction torques held to low values. Can operate at speeds to 2500 rpm, with up to 32 oz-in. of torque input. Installation in confined spaces or between cast-in supports is pos-

(Continued on page 150)

How to Simplify Fluid System Design

Get complete engineering and installation information *FREE!* Combination of new, illustrated Aeroquip 64-page Catalog *plus* 16-page Guide for Routing and Installation of Aeroquip Flexible Hose Lines will be sent to you. Just fill in coupon, detach and mail to us.

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Aeroquip Corporation, Jackson, Michigan

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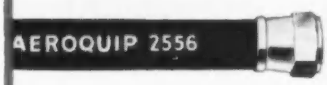
Specify These Aeroquip Flexible Hose Lines and Self-Sealing Couplings

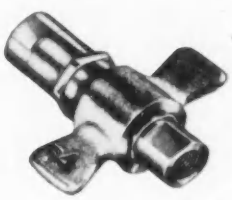
FUEL, OIL, WATER, HYDRAULIC LINES—Single Wire Braid 1503 and 1502 Hose for medium pressure hydraulic, water, hot oil, crude and fuel oil, anti-freeze, gasoline, diesel fuel and air lines. In sizes from ¼" to 2½"; pressures up to 3000 psi.; temperatures from —40°F. to +250°F. Also available: 2651 Rubber Cover Hose.

HIGH PRESSURE LINES—Double Wire Braid 1509 Hose for high pressure hydraulic, grease, crude and fuel oil, gasoline and air lines. In sizes from ¼" to 2"; pressures up to 5000 psi., depending on size; temperature range —40°F. to +200°F.

LOW PRESSURE LINES—Aeroquip 2556 Hose and *SOCKETLESS* Fittings for low pressure oil, fuel and air lines on all applications. In sizes from ¼" to ¾"; for pressures up to 250 psi., temperature range —40°F. to +250°F. *SOCKETLESS* Fittings in male pipe, S.A.E., J.I.C. threads. (Patent applied for.)



HIGH TEMPERATURE LINES—2802 Hose (Teflon) and Reusable ***"super gem"*** Fittings for fluid systems subject to high temperature and corrosive fluids. Hose and fittings can be assembled with ordinary hand tools. In sizes from ¼" to 1"; for pressures up to 1500 psi.; temperature range —100° F. to +500° F.



SELF-SEALING COUPLINGS—Type 5100 (wing union nut) and Type 5110 (hex union nut) allow quick connection and disconnection of fuel, oil, hydraulic and air lines, replaces two shut-off valves. There is no loss of fluid or inclusion of air into the system on connection and disconnection of fully pressurized lines. In O.D. tube sizes from ⅛" to 1½"; for pressures up to 2000 psi.; temperature range —40° F. to +250° F.

SOCKETLESS and ***"super gem"*** are Aeroquip trademarks

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AEROQUIP CORPORATION, JACKSON, MICHIGAN

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TAYLOR Laminated Plastics Vulcanized Fibre

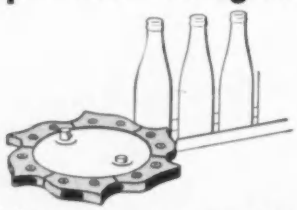
Shop Talk

TAYLOR FIBRE CO.

Plants in Norristown, Pa. and La Verne, Calif.

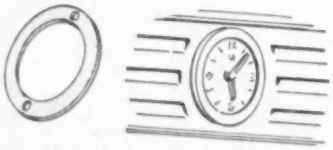
PHENOLIC—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

Tips for designers

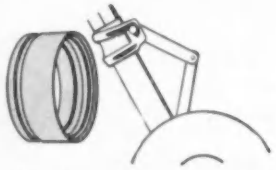


Indexing cams to position bottles under filling machines are made of Taylor Grade CEF phenolic laminate . . . replacing metal cams, they save money by reducing bottle breakage, avoiding rust.

Gas pump impeller unit is fabricated of Taylor Grade LE-6 phenolic laminate . . . economical, light-weight, wear-resistant . . . chosen because of strength, stability.



Automobile clock is securely and economically mounted on inside surface of metal dashboard, with a spacer fabricated from Taylor vulcanized fibre.

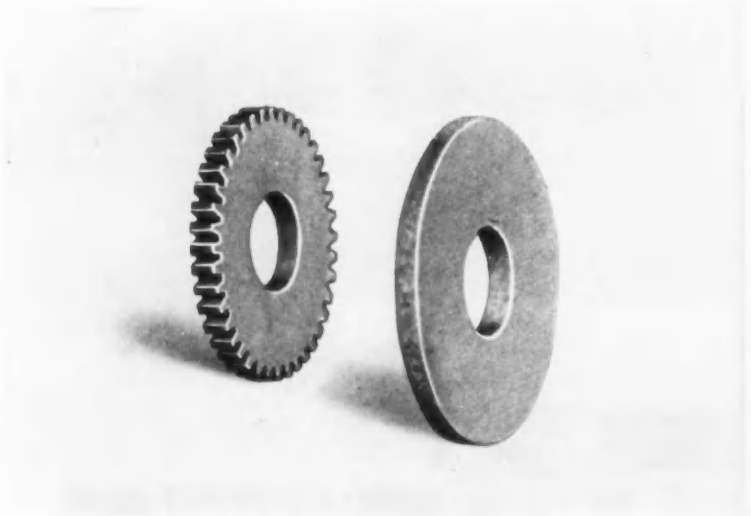


Aircraft landing gear bearings are fabricated of Taylor Grade LE-6 cotton base phenolic laminate to meet requirements of dimensional stability, wear resistance and low moisture absorption.

TAYLOR'S NEW COPPER-CLAD LAMINATE

Cu-246

. . . is now available for your volume production of printed circuits. High purity rolled copper surface is adaptable for all circuit production methods. **Cu-246** is produced in all standard sheet sizes . . . in thicknesses from .020″ to .250″.



Special purpose gear is fabricated of Taylor Grade CEF phenolic laminate for Hadley Gear Mfg. Co. Taylor punches the gear blank to an I.D. tolerance of ± .001″ . . . material was selected for its excellent punchability, good machineability, moisture resistance and impact strength.

Taylor delivers precision parts

. . . geared to your production schedule

The inside diameter of this gear blank was punched to a tolerance of ± .001″ by Taylor's Fabrication Division—an example of the close tolerances which Taylor can meet. Taylor has special techniques and facilities for handling this type of work—acquired through years of experience in fabricating all kinds of laminates.

Taylor Grade CEF phenolic laminate was selected as the material for the gear blank—to take advantage of this laminate's excellent punchability and machineability as well as its moisture resistance and impact strength.

You can put Taylor's facilities and techniques to work improving your product. Taylor can deliver precision parts, such as this gear blank, fabricated to your most exacting specifications . . . geared to meet your production schedule.

When you have a problem of material selection or close-tolerance fabrication, or product design, check with Taylor. Chances are that Taylor's staff of home and field office specialists can help you in any or all of these essentials to a good product. Call or write your nearest Taylor sales office for a discussion of your requirements.

Make good products better with stainless steels . . .

Stainless is a metal of lifetime beauty. But it's a lot more, too. And customers know it. They like its ease of cleaning, solid sturdiness, and practical utility. And they know that stainless products can't chip or peel . . . won't rust or discolor with use.

And to the designer and shop man, stainless presents no limitations or problems. It can easily be formed to complex shapes by usual shop methods.

Crucible is one of the nation's largest producers of stainless and other special steels. Deliveries are prompt and dependable, in the widest assortment of grades, sizes and finishes. And Crucible stainless specialists are ready to help with suggestions concerning selection or fabrication. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

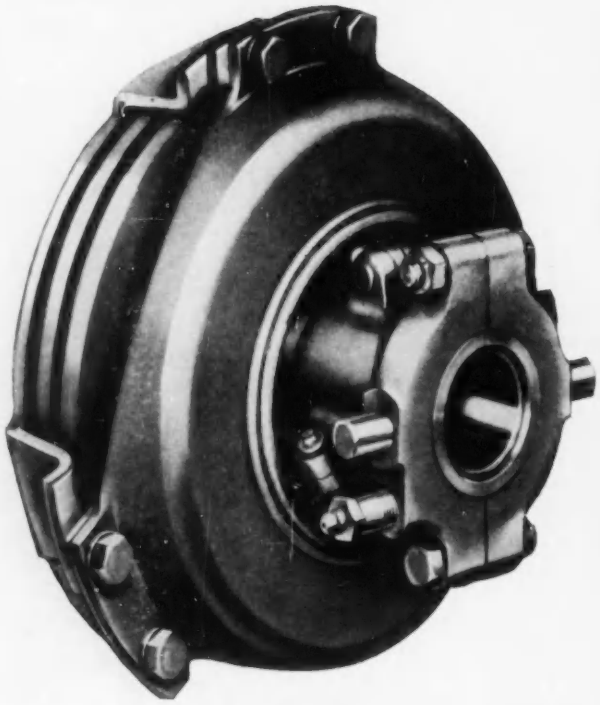
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

ROCKFORD

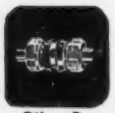
Single, Double or Triple Plate CLUTCHES



Small Spring Loaded

Automotive Spring Loaded

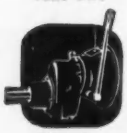
Heavy Duty Spring Loaded


Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs


Speed Reducers

Control POWER Better

The Over-Center, Spring-Loaded clutch shown above—when used in farm tractor LIVE POWER TAKE-OFFS—enables the harvesting unit to be controlled independently of tractor propulsion. It is used in various other ways and in other industries. And it is but one of many types and sizes of ROCKFORD friction CLUTCHES that have been designed and built to meet specific needs. If you have a special power control or power transmission problem, ROCKFORD clutch engineers will be glad to help you solve it.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

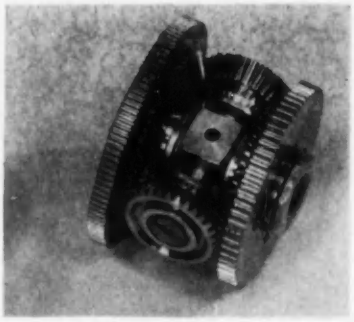
ROCKFORD Clutch Division BORG-WARNER

209 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

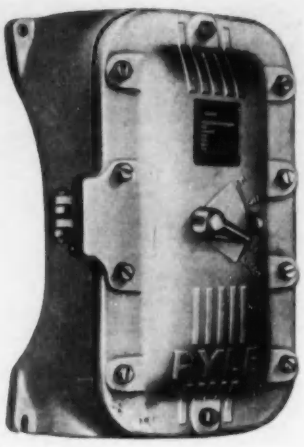
ENGINEERING B-W PRODUCTION

CLUTCHES



sible because of the hollow shaft design, which accommodates ⅛-in. and 3/16-in. shafting. Interchangeable end gears are available in wide tooth ranges for 48, 64, 96 and 120 diametral pitch. **Reeves Instrument Corp., 207 E. 91 St., New York 28.**

Circle 30, inside back cover



Explosionproof, dust-tight circuit breaker . . .

is also weather-resistant. Enclosures are available for breaker frame sizes from 100-amp, 250-v ac max to 225-amp, 600-v ac max. These airbreak type units are suitable for Class I, Group D (NEMA type VII); Class II, Groups E, F and G; Class III (NEMA types IX, V, III) hazardous locations. Enclosure is ferrous alloy, cadmium-plated throughout. Has single, hinged front cover. **Pyle-National Co., 1334 N. Kostner Ave., Chicago 51.**

Circle 31, inside back cover

Chain oiler . . .

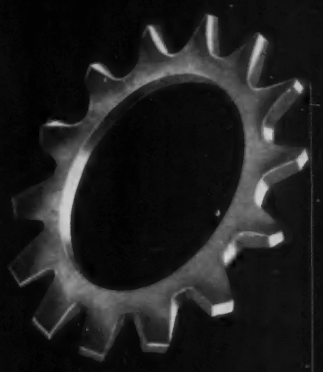
automatically applies a film of oil. Can be mounted at any convenient location. Oil is released by gravity from the reservoir to oil applicators either manually or elec-

(Continued on page 154)

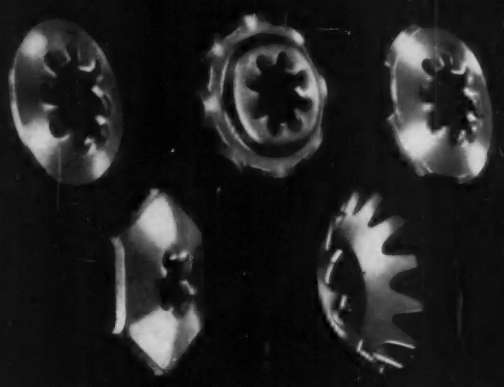
more

Locking Power

...than any other washer or washer substitute



SHAKEPROOF®
Lock Washers



Shakeproof locking teeth can be incorporated into many types of lock washers . . . for added strength, countersunk, and elongated holes, heavy-duty applications and other requirements.

• Shakeproof Lock Washers assure maximum vibration protection for your product • Exclusive tapered-twisted teeth resist loosening • Assure maximum locking engagement • Form positive brace against rotation • Resist shock • Available in nearly 500 job-tailored styles and wide size range.

Send for Shakeproof Lock Washer Sample Kit

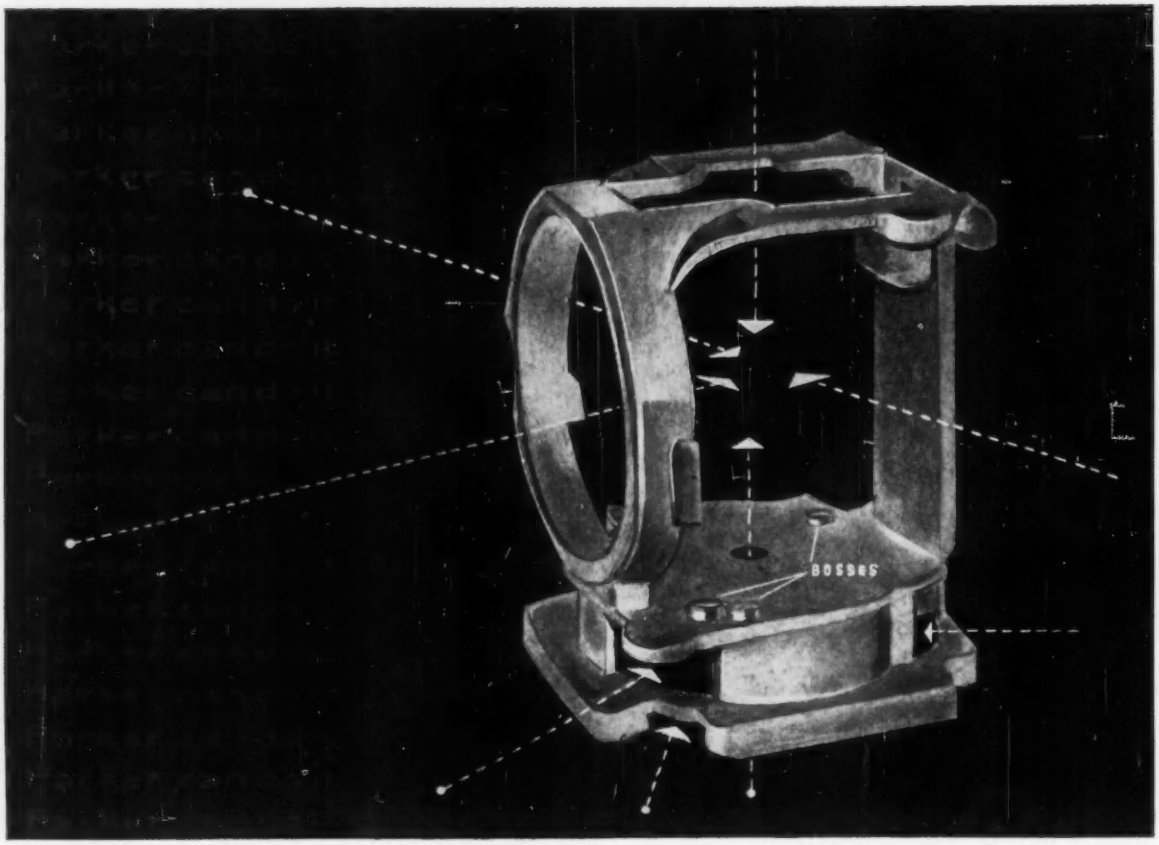
SHAKEPROOF

"FASTENING HEADQUARTERS"®

DIVISION OF ILLINOIS TOOL WORKS

St. Charles Road, Elgin Illinois • Offices in Principal Cities
In Canada: SHAKEPROOF-FASTEX, Division of Canada Illinois Tools, Ltd., Toronto, Ontario

itw



Coring Too Intricate For Die Casting?

----not at Parker

PARKER SALES ENGINEERS

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Warren G. Olson • 420 East Linn Street

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

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Hodgson-Geisler Co. • 18917 James Couzens

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LONG BEACH 11, California
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Fred B. Larsen • 6108 North 11 Avenue

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WILTON, Conn.
Girard L. Palmer • Belden Hill Road

WINTER PARK, Florida
Duane P. Davis • 110 South Orlando Avenue
Box 26

Because of intricate coring—together with internal bosses—sand casting seemed to be the only way to make this part. Necessary finish machining, however, boosted costs too high.

Then Parker die casting engineers tackled the job—and licked the coring problem. The result: a part with greater density, closer tolerances, better surface finish, no finish machining and—best of all—*much lower cost per unit.*

Here is just another example of the way Parker-engineered die castings save you money.

Parker has been a leader in die casting for over 50 years—an old hand with new ideas. This skill and experience can solve problems—and save money—on *your* component parts. Just call the nearest Parker sales engineer or send your prints to the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

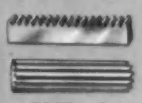
PARKER

high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

Plan your gear buying with "the book"

You'll be days... and dollars ahead

SPUR GEARS
14½° and 20° P.A.
.208" to 40" P.D.
Brass, steel, iron and non-metallic

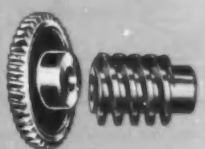


RACK and PINION WIRE
14½° and 20° P.A.
Brass and Steel

BEVEL and MITER GEARS
20° P.A.
.312" to 14" P.D.
Brass, steel, iron

SPIRAL MITER GEARS
1" to 5" P.D.

HELICAL GEARS
.333" to 6" P.D.
Bronze, hardened steel



WORM GEARS
.417" to 18" P.D.
Bronze and iron

WORMS
.333" to 4" P.D.
Soft Steel and Hardened and Ground Steel

The Boston Gear Catalog No. 56 is "the book" in constant use by men who specify and buy gears and other transmission parts, — for good reasons. They know it lists over 2000 types and sizes of standardized stock gears. They know that Boston Gears are top-rated for precision and performance. And they know, also, they can get

PROMPT DELIVERY OFF-THE-SHELF — FROM LOCAL DISTRIBUTORS — AT FACTORY PRICES

Why pay more (and wait) for "specials" when you can get Boston Gears FROM STOCK, nearby, to meet any specification? Be cost-wise . . . STANDARDIZE. Get your copy of Catalog No. 56. You'll be days and *dollars* ahead on any transmission job. Boston Gear Works, 71 Hayward Street, Quincy 71, Massachusetts.

CALL YOUR BOSTON Gear DISTRIBUTOR

For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

7124 STANDARDIZED TRANSMISSION PRODUCTS

Stock Gears • Sprockets and Chain • Speed Reducers • Bearings • Couplings

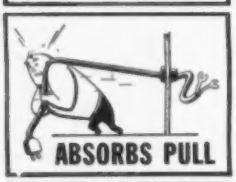
trically. Needle valves on the dispenser meter the right amount after initial setting. Manifolds are available that can be connected in series so that only one dispenser is needed for as many as 12 outlets. Applicators withstand temperatures to 275 F and can be trimmed to any width to avoid overhang and consequent side dripping. Oil supply is always visible through clear Pyrex glass or plastic cylinders. **Trico Fuse Mfg. Co., 2948 N. 5th St., Milwaukee 12.**

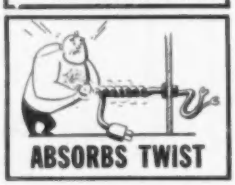
Circle 32, inside back cover

Machine tool switch . . . can control as many as four separate circuits for pilot or line duty. Actuation is adjustable in a full 360° sweep, on two different planes. Two types are available; a double action model is used to control switch contacts when actuator is moved to either side of center or the at rest position. Electrical rating is 2 hp, 230 v ac; 1 hp, 115 v ac; 20 amp, 125 to 250 v ac, and pilot duty, 250 v ac. Meets all NEMA

(Continued on page 156)

Tough
Heyco Nylon
STRAIN
RELIEF
BUSHINGS
Insulate and anchor the power supply cord to your housing . . .
no need for grommets, wire knots or costly labor.





Send for samples to fit your wire, today!

HEYMAN
MANUFACTURING COMPANY
KENILWORTH 3, NEW JERSEY

HEYCO

HEY MAN!
...SAY HEYMAN

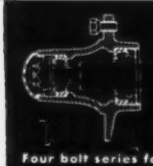
ELECTRIC
Wheels · Axles · Spindles

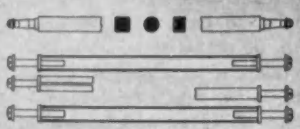
DIVIDED WHEELS
Generally used as dolly, tail or caster wheels

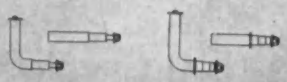
FOR TRUCK TIRES
Full drop center rim to utilize used truck tires on larger implements

PLANTER WHEELS
Steel rim or for use with planter rubber tires

SIX BOLT SERIES
Light and heavy—widest range of implement use


Four bolt series for light implements

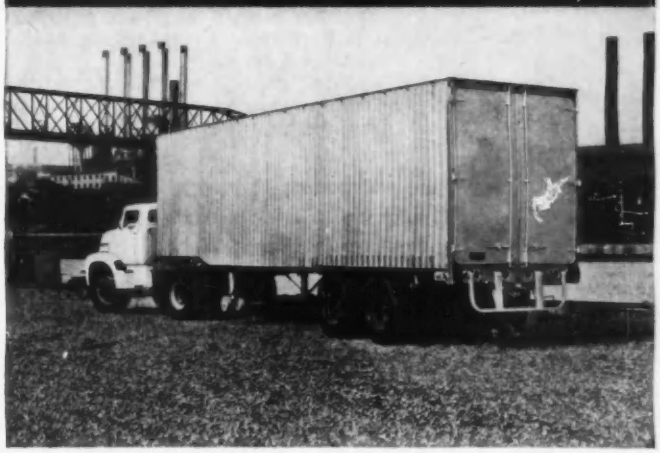

Hub and bearing combinations available. Stub spindles and full length axles.



Our Engineers Invite Your Inquiries
ELECTRIC WHEEL COMPANY
DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY
2805 SPRUCE · QUINCY, ILLINOIS

You can draw and form them LITTLE

or fabricate them BIG



with the new A-L low-nickel STAINLESS GRADES

WRITE FOR THE ASSISTANCE YOU NEED

1. "TECHNICAL STUDIES #3"

. . . essential information on the composition, properties, fabricating methods and applications of AL chromium-manganese, low-nickel stainless steels. *Write for your copy.*

2. TEST SAMPLES

. . . We'll be glad to supply engineering assistance, and actual samples of these 200-Series steels for testing under your processes and conditions.

ADDRESS DEPT. PE-95

In the top photograph, the fabrications you see are a mixing bowl, a tea-kettle base, a lock case and a patented shoe fastener: all made of A-L Type 201 or 202 chrome-manganese low-nickel stainless. The finish is good, the steel handled the same in the presses as Types 301 or 302, and similar drawing, buffing and polishing procedures were followed.

As in the lower illustration, the chrome-manganese low-nickel grades are being used also for fabrications as large as truck trailers and railroad coaches. Again, forming qualities and weldability present no problems, and results are entirely satisfactory.

Sum it all up and this is the answer: you *won't* encounter any particular differences in fabricating the 200-series of stainless steels . . . you *will* find some advantage in price, and a very important factor of much greater availability in times of nickel shortage. ● Why not take advantage of our pioneering experience with the low-nickel grades—let us help you use them. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

WSW 6060

For Stainless Steel in ALL Forms—call

Allegheny Ludlum

AL STAINLESS STEEL

Warehouse stocks carried by all Ryerson Steel plants

No. 25 Actual Size
Pitch 1/4" Width 1/8"

No. 35 Actual Size
Pitch 3/8" Width 3/16"

No. 41 Actual Size
Pitch 1/2" Width 1/4"

No. 40 Actual Size
Pitch 1/2" Width 5/16"

USE ACME CHAIN FOR EVERY POWER TRANSMISSION REQUIREMENT:

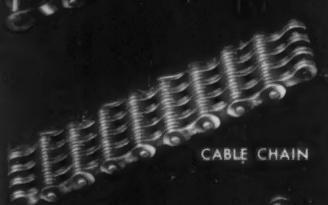
driving·conveying·timing

Acme Chains are efficient, economical and positive for power transmission. They are readily adaptable to any drive when maximum efficiency is essential. Correct principles of design provide operating characteristics superior to any other method of power transmission. Replacement parts always readily available from stock.

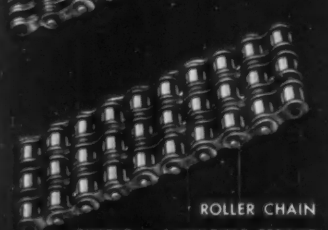
Your inquiry will place a skilled Acme engineer at work on your power transmission problems.

No. 50 Actual Size Pitch 5/8" Width 3/8"

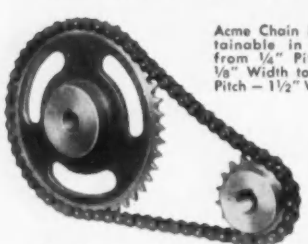
CONVEYOR CHAIN
STANDARD and
OVERSIZE
ROLLERS



CABLE CHAIN



ROLLER CHAIN
SINGLE and MULTIPLE STRAND



Acme Chain is obtainable in sizes from 1/4" Pitch – 1/8" Width to 2 1/2" Pitch – 1 1/2" Width.

Complete line of stock bore, steel and cast iron single sprockets, cast iron hub sprockets and all steel split or solid hub sprockets available.

FREE CATALOG

Write Dept. 1-R for your 80 page copy of Acme's latest catalog. Packed with valuable data.

Call
ACME
for Service

Acme Chain Corporation

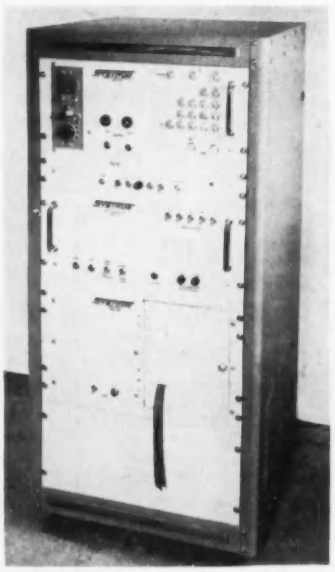
HOLYOKE
MASSACHUSETTS

and JIC requirements. **Acro Div., Robertshaw-Fulton Controls Co., Columbus 16, Ohio.**

Circle 33, inside back cover

Boards and standardized bases . . .
for drafting tables are available. The boards, of varying dimensions are interchangeable and offer fingertip lever-adjustment of working angle to 90° vertical. Other features are: print drawer the full width of the base, large reference top, metal edges on boards (which are sanded and finished with semi-gloss lacquer), and full-length guard rail. A bookshelf, second reference area, and adjustable base with simplified controls are available on one model. **Anco Wood Specialties, Inc., 71-08 80th St., Glendale 27, N. Y.**

Circle 34, inside back cover

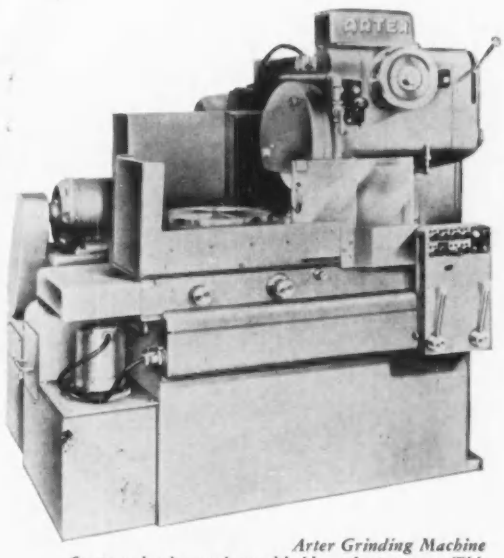


In-plant data handling . . .
is possible with this analog-to-digital data processor. Pressure, temperature, force, rate, acceleration or any variable that can be presented as an analog voltage may be

(Continued on page 159)

WELDED STEEL MACHINE BASE

costs less . . . is more rigid



Arter Grinding Machine Company has been using welded bases for ten years. This is a rotary surface grinder whose base and column were designed as a weldment to obtain rigidity with minimum weight.

ARTER GRINDING MACHINE COMPANY finds Welded Steel the economical answer to vibration in machine tools

The superior properties of steel have been employed by the Arter Grinding Machine Company of Worcester, Massachusetts, to achieve a more rigid, vibration-free machine at less cost.

The Arter engineering department emphasizes the advantages of weldments in the following statement:

> "Experience gained makes it possible to design a welded base of ample strength and rigidity to absorb vibrations and prevent the slightest distortion in lifting or moving a machine onto its foundation. Should a weak spot show up, it is a comparatively simple matter to weld in reinforcing gussets. Such a condition in a casting, on the other hand, becomes a more difficult matter to correct."

Because steel is more rigid and stronger than gray iron, less material is required to duplicate the strength of a casting. This economy of material combined with versatility—the ability to reinforce where necessary—provides a stronger, more rigid, vibration-free machine at less cost.

DESIGN HELPS FOR DESIGN ENGINEERS

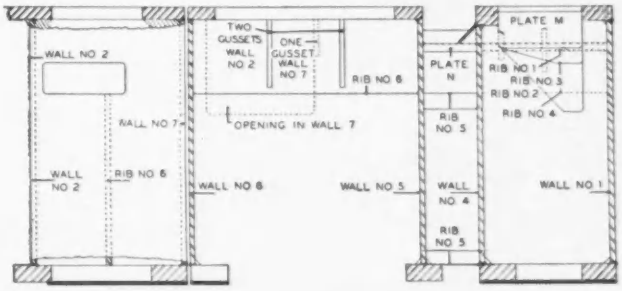
"Procedure Handbook of Arc Welding Design and Practice" 11th Edition. 1300 pages with latest procedures. Fully illustrated. Includes 240 page section giving latest developments in machine design. Price $3.00 postpaid in U.S.A. $3.50 elsewhere.

Seminars in use of Welded Steel in Machine Design for design engineers. Conducted regularly at Lincoln plant in Cleveland.

"Machine Design Sheets", with helpful ideas in applying welded steel, are free.

Write us for details.

Drawing of cross section of part of the base of the above machine.



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When steel is 2½ times more rigid

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Yet costs ⅓ as much per pound

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MEMO TO ENGINEERS—

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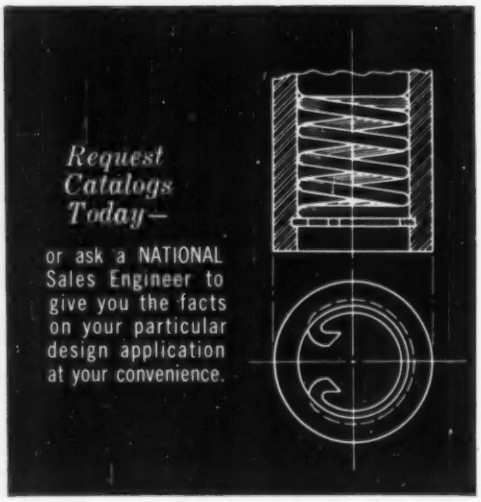
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...eliminate costly shoulders
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Installing NATIONAL Retaining Rings in simple grooves permits the use of smaller shafts and housings . . . saves machining and material wasted when larger shafts are cut down to make shoulders. Thousands of performance-proven applications include heavy machinery, engines, drill presses, tools, toys . . . products of metal, plastics and wood. Simplify the design of your products by utilizing the high efficiency of these easily installed NATIONAL Retaining Rings. Save weight, space, material, production and assembly time!

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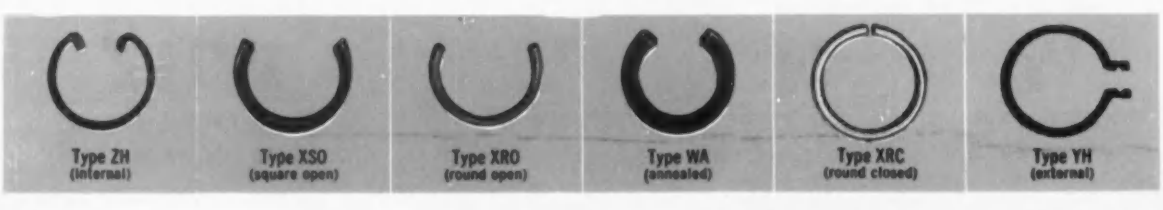
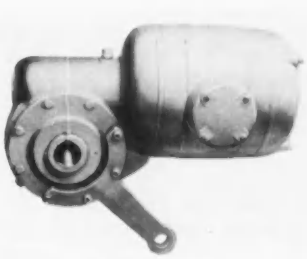


used as input information. Data are converted to digital form and made available as a direct-reading, in-line numerical, three-digit indication as a number printed sequentially on paper tape or in punched-tape form. Accuracy is ±0.1% of full scale. Smaller units are completely portable and may be hand-carried; larger equipment mounts on rubber-tired wheels for roll-around use. **Systron Corp., 2055 Concord Blvd., Concord, Calif.**

Circle 35, inside back cover

Transistor-equipped relay . . . requires 2 microw of power. Can be used in many applications with magnetic amplifiers. Designed for dc applications, the relays can pick up as low as 20 microamp at 100 milliv. Contact combination is from SPST through 4PDT. Contact capacity is 1 amp, inductive, or 3 amp, resistive, at 115 v ac or 29 v dc. Coil resistance is up to 30,000 ohm. Contacts may be of various metals. Relays are available open or with hermetically sealed dust cover. **General Automatic Corp., 12 Carlton Ave., Mountain View, N. J.**

Circle 36, inside back cover



Right-angle gear motors . . . are shaft-mounted to eliminate intermediate transmission elements. Available in ¼ through 5 hp. Made of aluminum, the

(Continued on page 160)

NEW DETREX

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(TRICHLORETHYLENE)

Now, "Dual Acceptance" means greatly increased efficiency and economy for solvent degreasing operations because PERM-A-CLOR* NA contains acid acceptors that assure a new high degree of stabilization. Functioning in both the presence and absence of moisture, these acid acceptors also provide outstanding resistance to the widest range of industrial soils on any metal or combination of metals.

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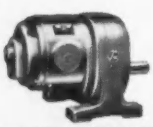
STERLING SPEED-TROL VARIABLE SPEED MOTORS

STERLING SLO-SPEED GEAR MOTORS



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STERLING ELECTRIC MOTORS

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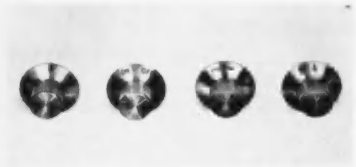
gear motor is built for continuous duty and meets AGMA specifications. The motor is especially suitable for light machinery or use in small areas. **Sterling Electric Motors, Inc., 5401 Telegraph Rd., Los Angeles 22.**

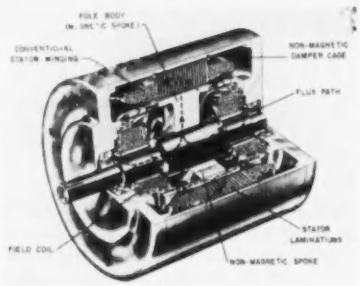
Circle 37, inside back cover



Aluminum instrument knobs . . .

are standard for ⅛-in. and ¼-in. shaft sizes with a variety of sizes skirted or unskirted. Twelve colors are offered. Special markings are available on the knobs. **Vemaline Products Co., P.O. Box 222, Hawthorne, N. J.**

Circle 38, inside back cover



Rotor moves brushless alternator . . .

and is its only moving part. Ceramic or other inert insulation is used to make the alternator suitable for temperatures beyond 800 F. Slip rings are eliminated and machine is inherently explosionproof. Rotor speed is limited only by centrifugal stresses in the solid metal rotor, and by bearing lubrication. Rectifiers for excitation unit are included in the altenator package rather than in separate box. Present range is from 0.5 to 125 kva, but larger requirements may be met. Suitable for air or ground applications. **Turbo-Machinery Div., Aerojet-General Corp., Azusa, Calif.**

Circle 39, insidt back cover

Explosion-proof switches . . .

have double conduit openings and reduce many installation costs that require through-wiring. UL-approved for hazardous atmospheres of Class 1, Group C and D; Class II, Group E, F and G. All switches have adjustable roller-arm actuators with nonsparking rollers. Alu-

(Continued on page 162)

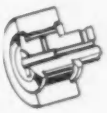
Performance features of TORRINGTON CAM FOLLOWERS

Heavy sectioned outer race to absorb high rolling and shock loads.

Integral stud for cantilever mounting, case-hardened, with tough core for high strength to withstand shock loads.

Easily relubricated at either end or through cross hole in stud. Ends accommodate standard drive grease fittings or plug seals.

Full complement of small diameter rollers for maximum radial capacity and efficient anti-friction performance.



Races precision ground for even load distribution and uniform low end play.

Built to "FOLLOW THROUGH" under high shock loads

Every feature of the Torrington Cam Follower is designed to insure efficient performance and long service life under heavy rolling and shock loads in cam or track follower service.

Precision made throughout, Torrington Cam Followers are available in sizes from ½" to 2¼" OD. Special surface finishes such as chrome and cadmium plate or oxide black can be provided.

Our engineering staff will be glad to work with you in applying these reliable units to your cam-controlled or track-type equipment. You can depend on Torrington Cam Followers to "follow through" on the job because every element is designed for ultimate capacity. *The Torrington Company,* Torrington, Conn.—and South Bend 21, Ind.

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NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

NEW DEVELOPMENT FROM

Robertshaw-Fulton

a combination low-cost

Temperature Control and Switch

with FIXED SETTING

Especially suited for use in restaurant coffee warmers, egg washers, heaters for livestock water tanks and many other applications where an economically priced control for maintaining a fixed temperature is required. This new "EU" Control, made of stainless steel for durable service, is permanently calibrated for any required temperature specified. For example, it may be slightly over 100°F for milk warming equipment, or 375°F for use in deep fat fryers, or even higher for commercial or laboratory equipment. Its compact design—dimensions are approximately 1½" diameter, 2½" high—permits its use in standard coils or elements.

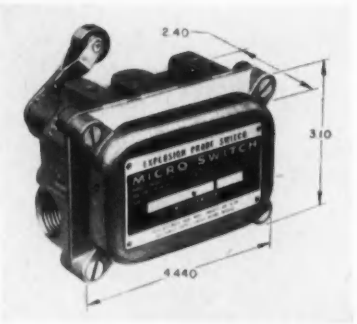
HERE'S A TYPICAL USE IN RESTAURANT COFFEE WARMERS

The new "EU" Control extends slightly above the coil. In this position the heat is off. But when a container of coffee is placed on it, the coil heats up to the pre-calibrated temperature of 180°F. Then it holds this temperature regardless of the amount of coffee in the container. It eliminates the problem of too much or too little heat.

For complete data write Department 41-1-EU2.

Robertshaw-Fulton CONTROLS COMPANY

ROBERTSHAW THERMOSTAT DIVISION • Youngwood, Pennsylvania

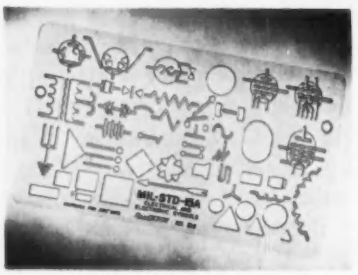


minum alloy housing, with room for wiring through both conduit openings, can be supplied for use with either ½-in. or ¾-in.-dia conduit. Available in SPST and DPDT contact arrangements, different-size conduit openings, and a wide range of electrical ratings. **Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.**

Circle 40, inside back cover

Portable potentiometer . . . has interchangeable scales. Measures temperatures from —200 to 600 F. Ordinary thermocouples are used. Will measure voltages from 0 to 21 milliv. Scales calibrated in centrigrade are also available. Equipment includes three aluminum disk scales for temperatures and one for millivolts, which are read directly without using charts, graphs or conversion tables. Has mercury-battery power supply and two-way scale drive with crank for rapid traverse and vernier knob for fine adjustments. Dimensions are 12¼ x 9 x 8½ in. Weight is about 14 lb. **Technique Associates, P.O. Box 91, Indianapolis 6, Ind.**

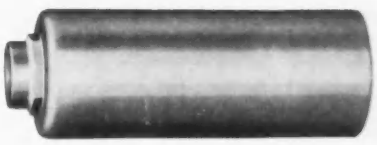
Circle 41, inside back cover



Electrical-electronic symbols template . . . is made of 0.040 mathematical quality plastic, designed for 0.2000-in. grid paper. Milled with bevel cut to facilitate drawing of latest symbols required by government for electrical components. Over-all size is 7 x 4 in.; price $4. **Rapidesign, Inc., P.O. Box 429, Burbank, Calif.**

Circle 42, inside back cover

Breaking fabrication barriers in new materials with cold forging!



Magnesium, Oxygen-free Copper, Zirconium, High Strength Aluminum Alloys

Most companies and engineering personnel are well acquainted with Hunter Douglas' activities in the field of cold forging aluminum and aluminum alloys. Not so well known are our efforts in the production of magnesium and oxygen-free copper components by the same process. Recently, as the result of a concentrated Hunter Douglas research program, tubular zirconium was successfully cold-forged... an achievement which now opens the door to the fabrication of other rare and costly metals by our cold forging techniques.

The field of cold forging is constantly expanding with many new successes destined for the future.

Where stakes are high and being "first" assures a competitive advantage—in lower cost, better design, greater strength—an original approach to your fabrication problem will pay dividends.

Hunter Douglas cold forging techniques, backed by an unmatched experience in this field, frequently supply the missing key. Many fabrication problems can be solved simultaneously by producing hollow, dense, zero-draft components meeting exact part geometry requirements and difficult performance specifications.

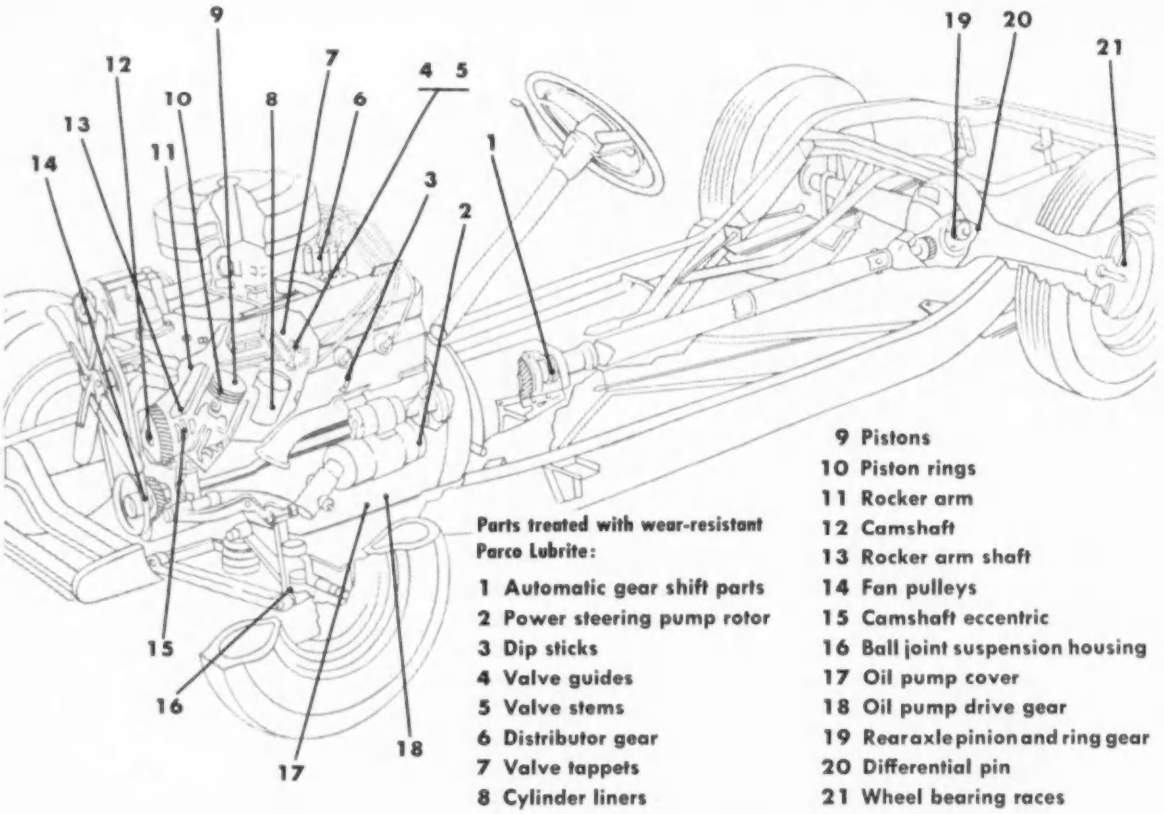
If you have production requirements in any of the metals now being regularly cold forged, we welcome the opportunity of reviewing prints and submitting quotations. Especially important, *if you have an advanced program involving zirconium or other rare metals*, we are in position to devote development facilities to the solution of specific high priority problems.

Among Hunter Douglas' many achievements is the first successful cold forging technique for zirconium ...a metal long believed unresponsive to this process!

By cold forging, the hard surface oxides, carbides and nitrides normally produced by hot working were completely absent, surface finish was good, and in tubular shapes tolerances on diameters and concentricity were held to a few thousandths... far superior to hot extrusions. With almost complete elimination of machining, metal waste was negligible... an extremely important factor with material costs running as high as $20.00 per pound!

Cold forging of oxygen-free copper is now proving important to the electronics industry and experimental development work is in progress on magnesium and even common metals, such as steel. Out of this extensive research program is coming the vital knowledge for meeting tomorrow's unusual problems. Look to Hunter Douglas for everything new in cold forging!

Hunter Douglas Aluminum
Division of BRIDGEPORT BRASS COMPANY
Dept.PE-11, Riverside, California, Telephone OVerland 3-3030



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11 Rocker arm
12 Camshaft
13 Rocker arm shaft
14 Fan pulleys
15 Camshaft eccentric
16 Ball joint suspension housing
17 Oil pump cover
18 Oil pump drive gear
19 Rear axle pinion and ring gear
20 Differential pin
21 Wheel bearing races

The automotive industry shows how to save money by using Parco Lubrite

Wearing surfaces—the vital parts that move or roll or slide against each other—can cost the manufacturer far more than their original price.

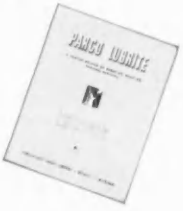
If one of them fails prematurely in use, because of improper break-in, there's the cost of replacement, the field service charge, and the customer's ill-will to be reckoned with.

To promote smooth, safe initial operation, to prevent galling, scoring and welding, and to lengthen subsequent life, friction parts should be treated with Parco Lubrite.

This nonmetallic, oil-holding coating eliminates metal-to-metal contact during wearing-in, keeps a film of lubricant between bearing surfaces, provides priceless protection for fractions of pennies.

Automobile manufacturers have cut field service costs by the use of Parco Lubrite. How about *your* product? Let the Parker technical representative investigate for savings!

DETAILED TECHNICAL INFORMATION

Technical bulletin, with photomicrographs and data, on Parco Lubrite wear-resistant coatings. Send for it. It's free.

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corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

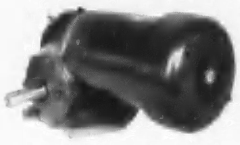
**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

Now... Century announces a completely new line of fractional-HP right angle shaft type GEARMOTORS

New, "Smaller and Better" 48 and 56 Frame Century Motors

Weight reductions up to 1/3
Gearmotors operate in any position
Compact design saves space
Tapered roller bearings on low speed shaft
Finest rotary face-type oil seal on high speed shaft
Wide variety of mounting and motor types

Single reduction AGMA output speeds from 25 to 280 RPM (Double reduction as low as 4 RPM)



For floor mounting, complete with new type 56-Frame totally-enclosed, fan-cooled motor. External fan fully protected by cover. Substantial mounting on gear housing supports overhung loads on shaft. Type SC three phase motor shown. Ratings up to ¾ HP.

New IR 40 with 48-Frame motor. Gear housing shown is in one of eight possible positions. Open type single phase capacitor-start Type CS motor. Strong welded foot assembly and heavy motor frame assure smooth operation with severe sprocket loading. Ratings up to ½ HP.

Typical special purpose mounting to suit driven machine. Output shaft is vertical downward extension, properly sealed against oil leakage. Capacitor-start type motor has special smooth cover over capacitor and terminal connections to facilitate cleaning to meet sanitary requirements. Ratings up to ¾ HP.

Basic horizontal unit as assembled with 56-Frame open type motor. Motor is Type SC polyphase. Multi-speed, crane and hoist duty and other special types available. Note convenient vent and filling plugs on gear housing. Ratings up to ¾ HP.

Call your nearby Century District Sales Office or Authorized Distributor

. . . Your best motor investment is Century

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Performance-Rated
MOTORS
1/20 to 400 HP

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Precise, yet rugged, too

Like Old Reliable here, MAC valves are proved performers. They're designed for dependability . . . precision built to operate *exactly*—cycle after cycle. That's because we demand much more from our valves than just ordinary duty. MAC spools, for instance, are engineered to withstand at least 75 times actual use load. MAC springs are "shot-peened"—a process that lengthens life by more than 1000% and virtually eliminates spring failure.

So it goes—*right down through the assembly line.* We build in the important "extras" that make the difference. And that's why you can expect more from a MAC valve—in performance, dependability and long life. Contact a representative listed at right. His know-how can help you with any air valve application.

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MAC

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 172.

INDUSTRIAL SHEET PACKING—Bulletin P-328, 8 pp. Detailed specs, engineering, application and testing data on 19 packings. Crane Packing Co., 6400 Oakton St., Morton Grove, Ill.

Circle 43, inside back cover

DRAFTING MACHINE—Bulletin, 2 pp. Describes machine and how it is used. Charts standard models for boards from 30 x 42 to 48 x 96 in. Glideline Corp., 300 S. Potomac St., Waynesboro, Penna.

Circle 44, inside back cover

ELECTRICAL CONTACTS—Folder, 4 pp. Has table of special and composite contacts, describes design and specs. Charts give dimensions of standard units. Contacts, Inc., 1100 Silas Deane Highway, Wethersfield, Conn.

Circle 45, inside back cover

SILICONE SPONGE RUBBER SHEETS—Data sheet, 2 pp. Properties of sheets available from stock, for —100 to 480 F applications. Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

Circle 46, inside back cover

VARIABLE SPEED V-BELTS—Catalog VS-10, 32 pp. Cross-reference information on variable speed V-belts for every type or make of unit. Interchange listings includes drive data and part-number listings of the manufacturers. Industrial Div., Dayton Rubber Co., Dayton 1, Ohio.

Circle 47, inside back cover

STAINLESS FASTENERS—Catalog, 48 pp. Stock list and data book. Part 1 includes illustrations, thread and design specs, and availability of corrosion-resistant metals for 40 basic fastening devices. Part 2 gives engineering data on composition, properties, applications and weights of stainless steels. Allmetal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N. Y.

Circle 48, inside back cover

GENERAL-DUTY MASTER SWITCH—Bulletin GEA-6705, 2 pp. Tables of ratings and dimensions are included with exploded view of features. Drawings show available handle modifications. General Electric Co., Schenectady 5, N. Y.

Circle 49, inside back cover

PVC PIPE—Catalog, 32 pp. Properties, applications and installation techniques. A chart classifies corrosion-resistance ratings. Tables show wall thicknesses, weights, burst pressure and recommended working pressure. Engineering Service Dept., A. M. Byers Co., Clark Bldg., Pittsburgh.

Circle 50, inside back cover

COMMERCIAL FASTENERS—Catalog 8-414, 12 pp. Fastener nomenclature, shear and tension values, and hole size recommendations, with a sequence drawing of the driving cycle. Dimensional information is tabulated, typical applications illustrated. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7.

Circle, 51, inside back cover

SUBMINIATURE INDICATOR LIGHTS—Brochure L-159, 4 pp. Describes lights for neon glow lamps. Several styles are shown and ratings and specifications given. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.

Circle 52, inside back cover

ELECTRICAL CONDUIT AND CABLE FITTINGS—Bulletin 85, 62 pp. Design, operational and installation features, sizes, number and weight. Index lists fittings according to conduit for which they are designed. Thomas & Betts Co., 36 Butler St., Elizabeth 1, N. J.

Circle 53, inside back cover

MAGNESIUM AND ALUMINUM ALLOYS—Catalog 57, 20 pp. Physical properties and conforming specifications. Listings include alloys for sand castings, permanent-mold and rare-earth alloys. Wellman Bronze and Aluminum Co., 12800 Shaker Blvd., Cleveland 20.

Circle 54, inside back cover

TUBE AND BAR STOCK—Bulletin 156, 6 pp. Information on standard bar and tube stock in Meehanite metals, and Type 1 Ni-Resist. Illustrates uses. Contains physical-properties chart. Shenango Furnance Co., Dover, Ohio.

Circle 55, inside back cover

DOUBLE-REDUCTION SPEED REDUCERS—Bulletin CD-230, 20 pp. Covers 164 standard styles and sizes. Selec-

(Continued on page 170)

MOTOR MAINTENANCE TIP:

Use Shovel Regularly

Without the vigorous use of a shovel, this Fairbanks-Morse 100 hp. motor would be buried under corrosive coal dust. Even so, as it drives a briquette press 16 hours a day, there is a cloud of coal dust coating motor windings and inhibiting normal cooling . . . steam and sulphur release sulphuric acid that can cause mechanical and electrical failure.

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There is no better way to judge design advantages than to look at the long performance record of equipment in service. Your nearby Fairbanks-Morse Motor Specialists can show you many applications similar to your own.

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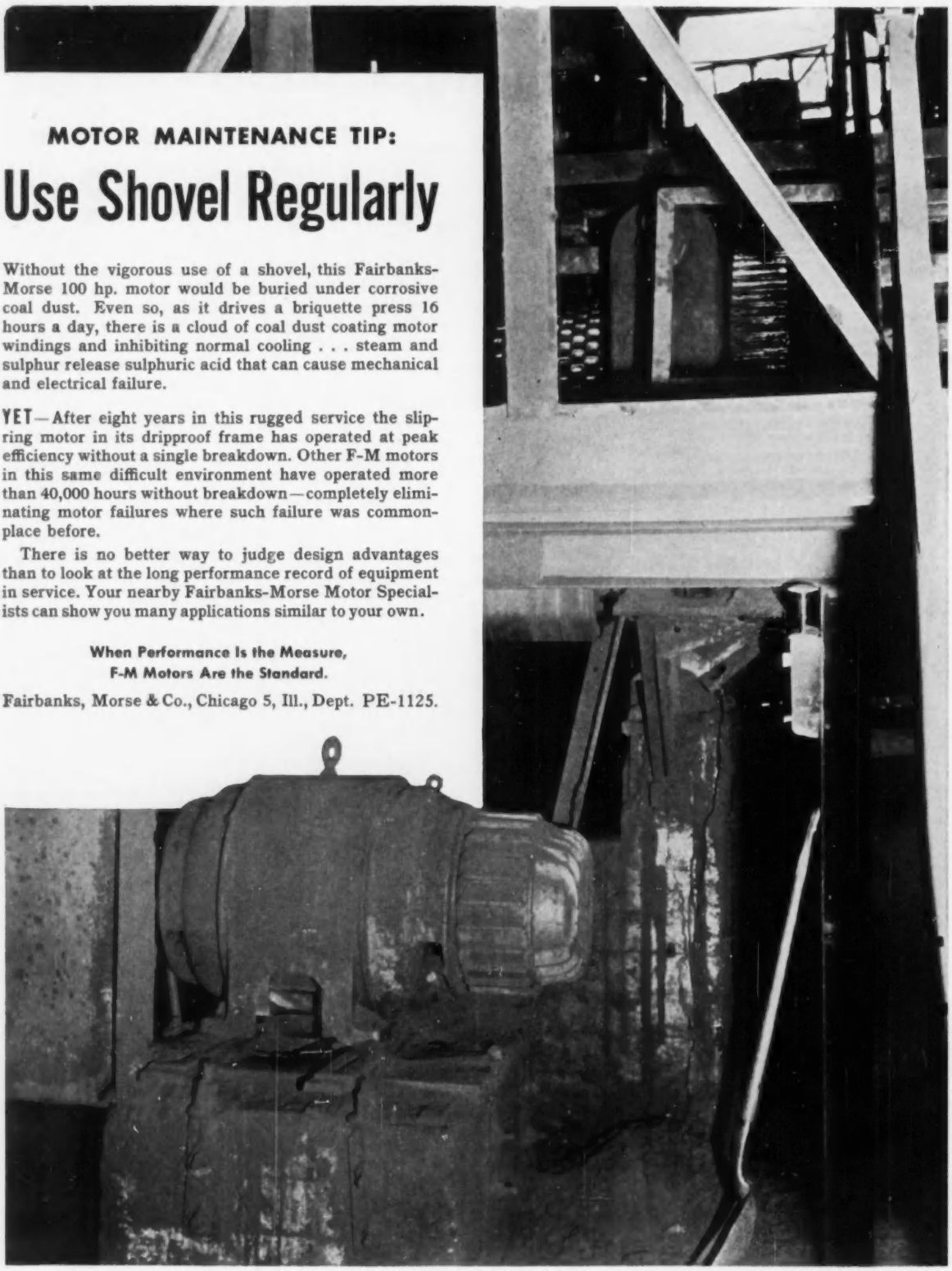
F-M Motors Are the Standard.

Fairbanks, Morse & Co., Chicago 5, Ill., Dept. PE-1125.



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hoover locks lube in, dirt out for the lifetime of the bearing

Hoover is first to seal ball bearings with TEFLON! Hoover makes *sure* that lube stays in, dirt stays away from the smooth, mirror-like working surfaces of high quality *Micro-Velvet* Lapped Balls and *Hoover Honed* Raceways. You get greatly extended bearing life.

Why TEFLON for seals? TEFLON is the remarkable new product of chemistry . . . extra tough . . . extra long wearing . . . and so slippery that there is practically no torque resistance. Hoover seals are ingeniously engineered to maintain positive contact and improve lube circulation. Permanently attached full metal shields lock the seals within the bearing, safe from damage.

Use Hoover Ball Bearings with single or double seals of TEFLON for high speed applications, electric motors, or wherever periodic lubrication or maintenance is not practical, as in sealed units. They are available in both light and medium series.

*TEFLON is DuPont's Trademark for its Fluorocarbon Resins.
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(light, medium, heavy series)

- Single and Double Shield
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Ann Arbor, Michigan

Please mail my copy of Bulletin No. 100 on Hoover Bearings with Seals of TEFLON.

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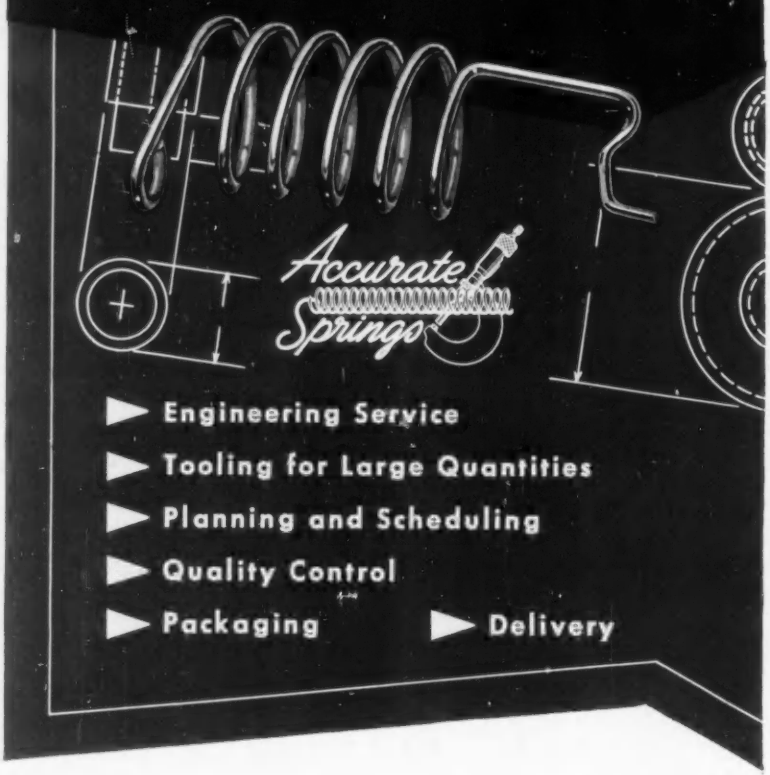
14

Design for a Successful Spring



These are the basic elements necessary to design and produce a precision built spring. To supply the above elements takes skill, experience and imagination . . . ingredients that Accurate Spring provides every one of their customers every day.

Accurate makes millions of springs a month—precision springs held to close tolerances by rigid quality control and inspection. Production schedules for large quantities are planned well in advance. Customers are assured of deliveries scheduled to their needs.

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Accurate Springs | SPRINGS WIRE FORMS STAMPINGS

ACCURATE SPRING MFG. CO., 3815 W. Lake St., Chicago 24, Ill.

tion data includes capacities, types and ratios. With dimensional drawings. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12.

Circle 56, inside back cover

SWITCHES—Catalog, 36 pp. Specs on rotary, slide and lever switches. Illustrated and indexed. Centralab, Div. Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee.

Circle 57, inside back cover

HEAVY-DUTY MASTER SWITCH—Bulletin GEA-6706, 8 pp. Features, modifications and operating advantages of surface and desk-mounted models. With drawings of configurations and dimensions. General Electric Co., Schenectady 5, N. Y.

Circle 58, inside back cover

WELDING AND CUTTING—Booklet ADG-2057C, 20 pp. Describes publications and audio-visual items available without charge. Publications cover applications of industrial gases, welding and cutting techniques, and equipment. Lists motion pictures that show latest developments in automatic welding, machine gas-cutting and other processes and products. Air Reduction Sales Co., div. Air Reduction Co., Inc., 150 E. 42nd St., New York 17.

Circle 59, inside back cover

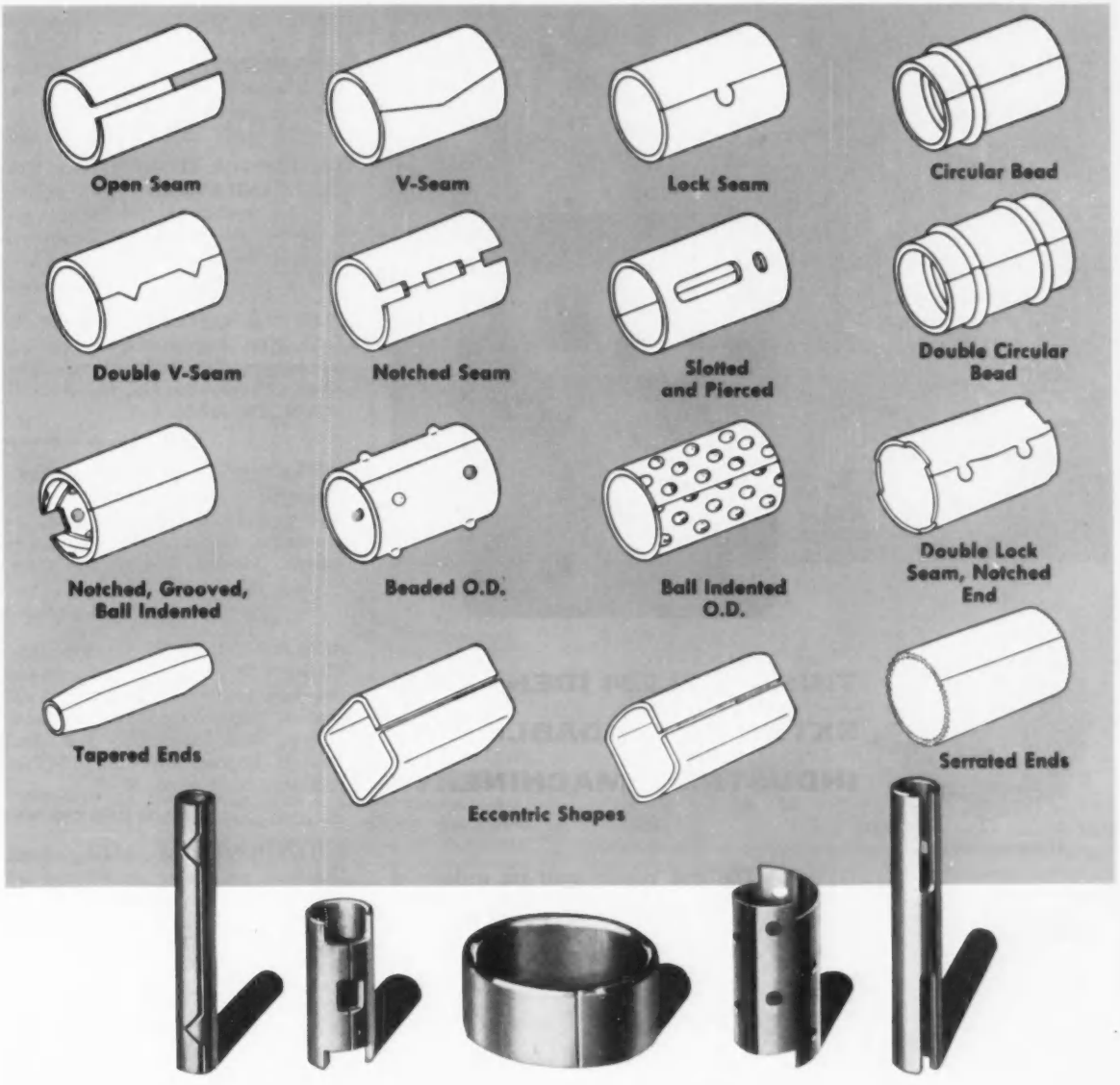
HAIRSPRINGS—Handbook, 8 pp. Guide for selection of materials for specific operating conditions. Tells how to specify physical requirements, discusses relative importance to be given to effect of torque, OD, cross-section and collet hole size. Associated Spring Corp., Bristol, Conn.

Circle 60, inside back cover

ELECTRONIC CONNECTORS, COMPONENTS—Company publication, 4 pp. First issue of **Electronic Connector**, a

(Continued on page 172)

"Terrific idea, Hoskins! We'll use sandwich construction!"



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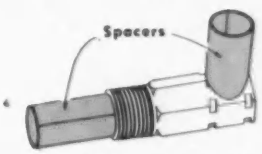

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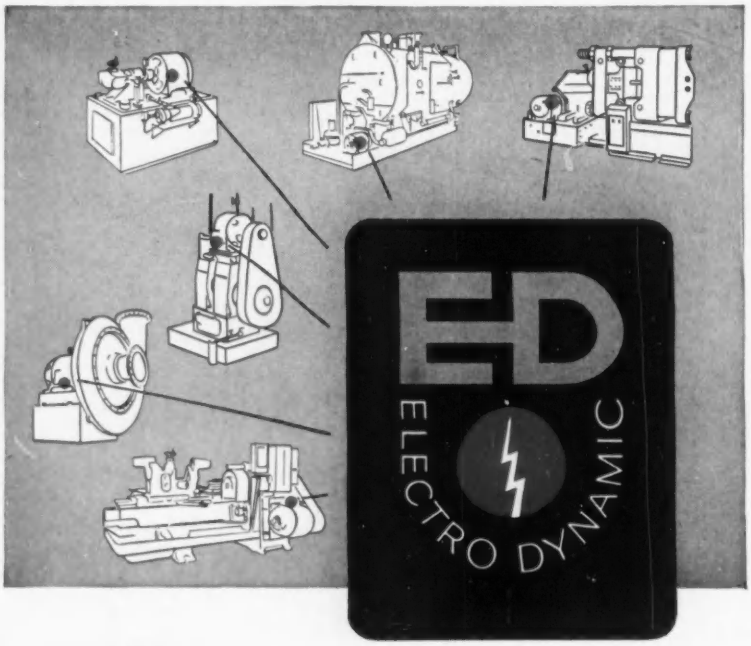

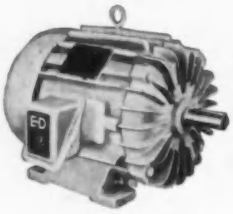

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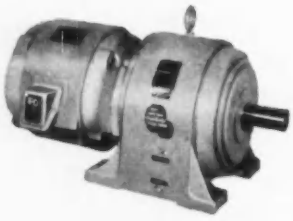

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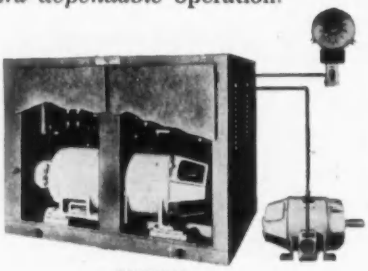

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quarterly. New products and developments are reviewed. H. H. Buggie, Inc., Box 817, Toledo 1.

Circle 61, inside back cover

FILTERS FOR FLUID POWER CIRCUITS AND LIQUID LINES—Bulletin 17, 4 pp. Applications, characteristics and properties. Filtros, Inc., 607 Commercial St., East Rochester, N. Y.

Circle 62, inside back cover

FLEXIBLE TEFLON TUBING—Bulletin 4, 2 pp. Properties, applications and case histories of standard stock sizes. Pennsylvania Fluorocarbon Co., Inc., 1115 N. 38th St., Philadelphia 4.

Circle 63, inside back cover

DC MOTORS AND GENERATORS—Catalog SP-182, 6 pp. Cutaway drawings show general construction. Included are dimensions, ratings and applications in industry. Marathon Electric Mfg. Corp., Wausau, Wis.

Circle 64, inside back cover

REMOTE CONTROL ASSEMBLIES—Catalog 5694, 12 pp. Flexible shafts and couplings, universal joints, and push-pull controls. Includes properties and specifications. With illustrations, dimensional drawings. Kupfrian Mfg. Corp., 137 Prospect Ave., Binghamton, N. Y.

Circle 65, inside back cover

POTENTIOMETERS — Catalog sheets. Illustrated engineering specifications on seven new and standard models. In file-folder form. Spectrol Electronics Div., Carrier Corp., 1704 S. Del Mar Ave., San Gabriel, Calif.

Circle 66, inside back cover

SELF-LOCKING CONNECTORS—Brochure, 24 pp. Catalog of connectors made by Harvey Hubbell, Inc., Bridgeport, Conn. Gives electrical and mechanical characteristics. Photos, dimensional drawings and sketches. Avnet Interlock Corp., 8966 National Blvd., Los Angeles 34.

Circle 67, inside back cover

Letterhead Requests Only

Manufacturers who publish following literature ask that requests for copies be made on company letterheads.

FREE-PISTON ENGINE—Booklet, 36 pp. Specifications and estimated performance data on FP-165 turbocharged, free-piston engine. Traces development through five designs. Diagrams, specifications and performance characteristics on each prototype model. Cutaway diagrams illustrate construction. Hamilton Div., Baldwin-Lima-Hamilton Corp., Hamilton, Ohio.

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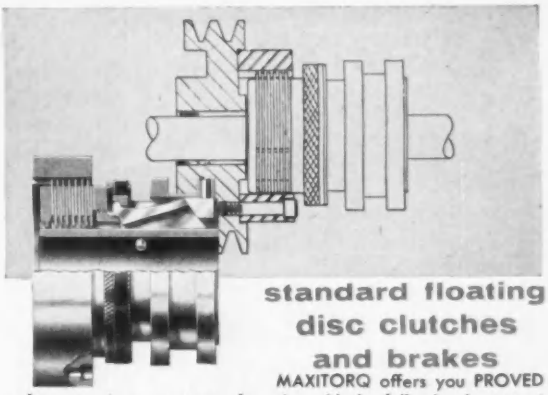
PROVED design, Floating Disc action is fast and positive, with no heating or drag in neutral. Compact, simple, with few moving parts. For WET or DRY operation: Electrical operating unit DOES NOT REVOLVE; no brushes or slip rings. Use easily replaced standard Disc-Pac. Requires no adjustment. Wide range of standard sizes, single and double types. All sizes rated 80 watts, operate on 110 V, A.C., rectified to 90 V, D.C. Other voltages on special order.



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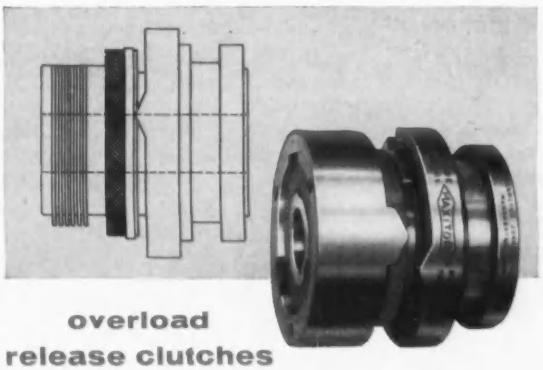
MAXITORQ offers you PROVED performance in every type of service with the following important advantages: compact design with few and sturdy parts . . . floating neutral with no heating or drag . . . positive engagement or release with light pressure . . . manual assembly and adjustment . . . full power transmission . . . full range of sizes and types . . . supplied as complete, easily installed units.



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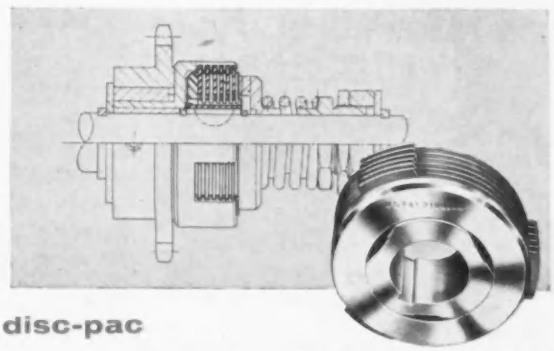
One of the simplest and most efficient methods of providing a DEPENDABLE and easily adjusted overload release on machines requiring this safety feature in addition to a clutch. Incorporate all the advantages of MAXITORQ Floating Disc design plus automatic and complete release upon overload. Proved in service. Available in a wide range of sizes.



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The "heart" of the SERVICE-PROVED Maxitorq Floating Disc Clutch in a compact, assembled unit for those who wish to design and build their own clutch mechanisms. Supplied as complete units ready for use in 8 diameters 2" to 8", up to 800 ft. lbs. capacity. Also useful as a multiple disc brake or torque limiting device.

Write for complete data and specifications on any or all of the above. If you have a problem involving clutch applications, consult us. A letter or phone call will receive prompt attention. Dept. PE-11.

M THE CARLYLE JOHNSON MACHINE COMPANY, MANCHESTER, CONN.

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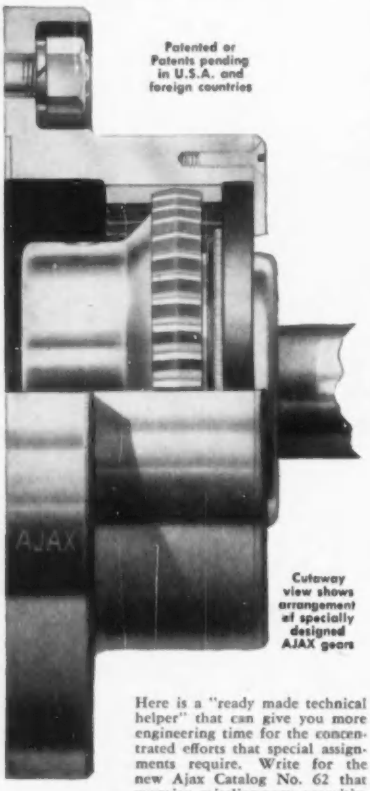
Self-aligning

DIHEDRAL COUPLINGS

Short Cut to Major Product Improvement



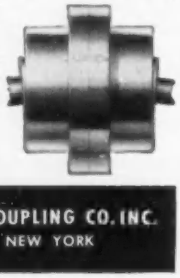
Patented or Patents pending in U.S.A. and foreign countries

Cutaway view shows arrangement of specially designed AJAX gears

Here is a "ready made technical helper" that can give you more engineering time for the concentrated efforts that special assignments require. Write for the new Ajax Catalog No. 62 that contains misalignment capacities of every coupling size and type in the complete line of Ajax Dihedral Couplings. Why spend valuable time duplicating data already established by thousands of proven, field tested applications.

Ajax Dihedral Couplings handle unavoidable shaft misalignment, angular and offset, up to a total of 12°. Teeth can be cut to handle greater misalignment capacities on special order.

Get the facts on how manufacturers of presses, machine tools, rolling mills, cranes, earth moving and many other direct connected machines are simplifying design, cutting manufacturing costs and improving product performance with Ajax Dihedral Couplings.



Write today for your personal copy of Bulletin No. 62.

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, NEW YORK

DESIGN ABSTRACTS

Electrical and Mechanical Properties of Epoxies

For a constant epoxy resin composition, changes in volume resistivity and flexural strengths will parallel one another in the temperature range immediately below and above the temperature level indicated in ASTM heat-distortion test procedures. However, the heat distortion temperature cannot be predicted from data developed for epoxy resins. A general observation that can be made is that a broad relation exists between the Shore D hardness of an epoxy resin and its volume resistivity.

The resilient epoxy resins will depict significant electrical and mechanical property changes on long-time aging at elevated temperatures. It may be possible to employ nondestructive dielectric measurements for tracing changes in the epoxy resin compounds. Also reported was an increase in volume resistivity upon the application of small tensile stresses.

Abstracted from "Relationships between Electrical and Mechanical Properties of Epoxy Plastics," John Delmonte, Furane Plastics, Inc., ASTM Bulletin, Sept. 1957.

Rupture and Impact Stresses in Reinforced Plastics

A method is proposed for evaluating strength data as a function of time and temperature. The method involves determination of rupture properties at various temperatures for extremely short and long periods of time. Mathematical and graphic relationships are included.

Abstracted from "Long-term Rupture and Impact Stresses in Reinforced Plastics," by Solomon Goldfein, U. S. Army Engineer Research and Development Laboratories, ASTM Bulletin, Sept. 1957.

Internal Load Reaction in Rolling Bearings

Determining loads on individual rolling elements in single-row and double-row bearings of various types, under external load applied at any angle to the bearing axis, was first dealt with by Stribeck. His research was confined to effects of true radial load only on bearings with contact angle $a = 0°$, thus limiting the scope of his classic formulae. The analysis given here relating to angular-contact bearings requires only elementary mathematics, trigonometry and mechanics. Each step is given in detail to elucidate principles underlying analysis, encouraging use of tables provided, because they are not subject to blind acceptance.

Abstracted from "Internal Load Reactions in Rolling Bearings," by R. K. Allan, Mechanical World, Sept. 1957.

Engineering Is What We Make It

More people are now engaged in providing the services portion of the Gross National Product than in producing goods. Science and engineering have been steadily turning production drudgery over to machines. But society is deeply concerned with the possible impact of science and engineering on the future of the race.

In receiving and appraising the engineer's contribution, society—to an increasing degree—will seek assurance about his qualifications, his motives and his integrity. Engineers are faced with the double task of adding to the reputation of the engineering profession, while making sure that technological contributions are properly evaluated and put to good use.

More than publication—or publicity—is needed to help the community appreciate the full implications of technological developments. It may involve years of missionary work plus close cooperation among all professionals to put those developments to work.

The professions would do well to foster mutual respect for the achievements of others and for their contributions to total progress. This builds a sound basis for development and

(Continued on page 176)

Help Fight TB

Buy Christmas Seals

Expanded metal can fit into your plans, too

Penmetal expanded metal used for delicate-fabrics compartment of clothes dryer. Strong, smooth open mesh allows warm air to circulate freely.

Penmetal expanded metal, introduced at the planning stage, can often mean the difference between failure and success of products like these. That's why so many top designers are taking advantage of its valuable properties—why you should, too!

Decorative . . . its clean, modern look puts sales appeal in your product. Functional . . . the diamond truss pattern adds strength; permits the free passage of sound, heat and air. Made of sheet steel, which is slit and stretched from one to ten times its original width, expanded metal is up to 80% lighter than solid sheet of the same dimensions. And, cost is moderate.

Penmetal expanded metal comes in carbon steel, aluminum, stainless steel, Monel, Inconel, etc. Large or small mesh. Light or heavy gauge.

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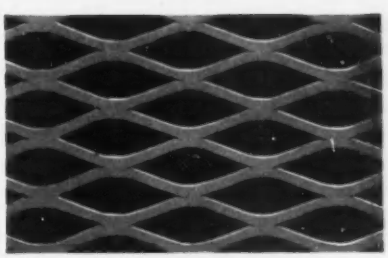
Penmetal expanded metal adds strength with light weight and beauty to gossip bench.

TV speaker grille of expanded metal: handsome, strong, protective.



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1869
OF QUALITY

a name to remember

Waldron couplings on a fan drive of jacket water coolers.

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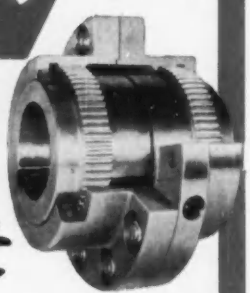

STRENGTH — Hubs and cover sleeves for sizes 1¼ A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

RELIABILITY — There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is positioned where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

SERVICE — Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

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Representatives In Principal Cities

proper use of the great engineering contributions to come and for genuine prestige for engineering.

Today the frontiers of engineering are moving so fast that possession alone of a particular degree or body of experience is a poor guarantee of continued contributions. Whole areas of established technologies may become obsolete twice or even three times in one man's lifetime. No one can expect to wrap himself in his sheepskin or his past experience and settle down for a nap.

How is this situation met? Primarily, I should say, by simply doing one's job better. Engineering jobs done well provide growth and recognition for the engineer and add to the stature and reputation of engineering as a profession.

Abstracted from editorial by C. H. Linder, General Electric Review, Sept. 1957

Design for Reliability

Reliability and maintainability are intimately tied together through the five categories of reliability from "safety reliability" to "overhaul." By defining the intended reliability and establishing working goals susceptible to measurement, the designer can get his teeth into the problem.

Design breaks into two types: initial design, and correcting problems that show up in use. Methods of evaluation and measurement will make it possible to treat reliability as other engineering subjects have been, and will result in major improvements in all five categories of reliability.

Abstracted from "Design for Reliability", by G. S. Schenier and H. S. Clayman. Presented at SAE National Aeronautical Meeting, Los Angeles, Calif., Sept. 30-Oct. 5, 1957.

"Do you think Thomas Edison sulked when he had to put in a little overtime?"

As a supplier of welded rings and components to major United States jet engine manufacturers, American Welding has proven its skill as part of an industry where cost and precision are vital factors. As the missile and rocket programs grow from the experimental to the production stage, Amweld's experience and skill can play a part in these essential programs.

If you have a problem that can be solved by a rolled and welded ring or component, or any welded fabrication, contact American Welding's Industrial Products Division. Their skill, experience, and engineering are at your service.

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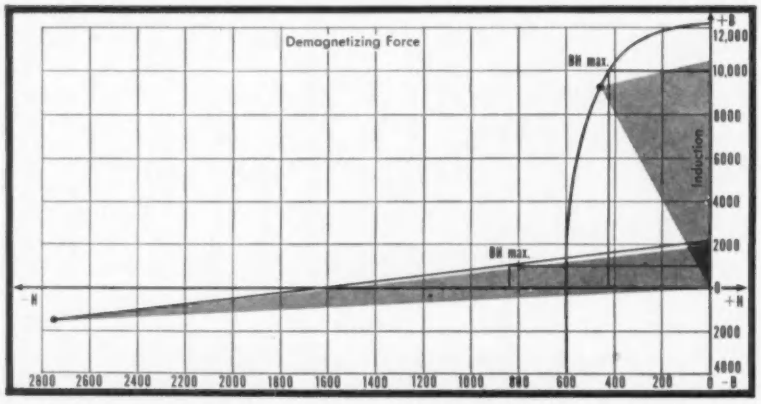

Composite of demagnetization curves showing that for Alnico V, upper, and Indox I, lower. Operation in the third quadrant is produced when a demagnetizing force, stronger than the magnet, forces flux in a direction opposite normal operation, providing negative magnetic induction. Indox magnetic flux returns to full value when this force is removed.

Why Ceramic Magnet Fields Are Now Practical for D.C. Motors

G. R. Hennig, Senior Design Engineer, The Indiana Steel Products Company, explains in this interview why Indox ceramic magnets are now practical for d.c. motors ranging from fractional to multiple horsepower.

Question: Why is the use of Alnico magnets limited to rather small motors, such as toy motors? Why are only some very special larger motors equipped with permanent magnet stators at the present time?

Answer: The price per unit of usable magnetic energy dictates the size limit. Alnico contains very expensive raw materials. For small magnets weighing a fraction of an ounce, this is not too significant. Labor cost, however, the other main factor in any calculation, is a sizeable item in small units. This is not true when larger Alnico magnets are required. With Indox the opposite is true. Its raw materials are cheaper than copper, and it appears that the larger the motor—within a certain limit—the more economically the material can be applied.

Question: How can Indox I, with only ⅕ the energy product (BH_{max}), of Alnico V, be recommended for motor usage where a high field energy is required?

Answer: Maximum energy product is a good criterion of quality for static conditions, such as in the magnet systems of moving-coil instruments or loudspeakers. In motors, generators, and many other applications where the magnet is subject to strong demagnetizing forces, maximum energy product is not an important consideration. One must consider the incremental permeability, even in the third quadrant of the hysteresis loop. The result is, that under the most extreme conditions, Indox I has a maximum usable energy of 17.4 in.-lb. per pound while Alnico V has only 13.7 in.-lb. per pound. Under conditions as found in motors, the usable energy of Indox I is about ½ instead of ⅕ of the usable energy of Alnico V.

Question: How does Indox V compare with Indox I and Alnico V, and where does this material find application?

Answer: Indox V is the strongest ceramic magnet material available today. Per unit of volume it provides more usable energy in motors than Alnico V does. Flat pieces with at least 2 sq. in. area are preferable for production. This means that Indox V is suitable for motors with about 1/25 hp and more, and not for the tiny toy motors.

Question: What are the size limitations for Indox I and Indox V motors?

Answer: Indox I is suitable for motors from the smallest possible size to about ⅛ hp. Indox V can be applied in much larger motors, possibly in the range up to 10 hp, or higher. The same applies for generators.

Question: Can any d.c. motor be converted to a permanent magnet-field motor?

Answer: Yes, most motors can be converted with very little design change. Others may require a considerable change in structure and layout of the armature.

Question: Is there a problem of meeting air gap tolerances with Indox I ring or segment stators, unless bore grinding is applied?

Answer: No. Even though there is an as-sintered tolerance of ± 1.5%, an Indox magnet may be compared with an air-core solenoid, and variations of the air gap length have little influence on the usable flux. Only the O.D. should be ground which is an inexpensive operation on centerless grinders.

Question: How will a permanent magnet motor compare with shunt or series wound motors?

Answer: In general, a permanent magnet motor will have characteristics falling between shunt and series wound motors. Although it will not duplicate the entire speed torque curve for either, it can duplicate characteristics over a specified range.

Question: What are the specific advantages of substituting permanent magnets for wound fields in motors?

Answer: The advantages are: Higher efficiency, cooler operation, less use of critical material such as copper and, possibly, simplification and cost reduction.

Question: Is there a possibility of using Indox in a.c. motors?

Answer: Yes. In addition to various synchronous timer motors, d.c. motors with Indox magnets can be used with the new, efficient power-rectifiers (silicon or others). The advantages over normal d.c. motors are higher starting torque and better speed regulation.

Question: How is the speed controlled in permanent magnet motors?

Answer: Normally, by varying the armature voltage, but also by using a magnetic shunt, by moving the armature axially out of the permanent magnet field, by rotating the brushes, or by an auxiliary field winding.

Question: Can a permanent magnet stator compete with an equal electromagnetic stator in size or total volume?

Answer: Yes, with the materials we have today it can. There is only one exception: Where wound fields are operated with high, short-time overloads.

A complete reprint of Mr. Hennig's paper, "Applying Ceramic Permanent Magnets to Motor Design" appears in the July-September *Applied Magnetics*. Write today for your copy. **Dept. C-11.**

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VALPARAISO, INDIANA

THE WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS

INDIANA PERMANENT MAGNETS

In Canada . . . The Indiana Steel Products Company of Canada Limited, Kitchener, Ontario

NEW BOOKS

Analysis of Bistable Multivibrator Operation

P. A. NEETSON, *Book X, 6 x 9 in., 82 pp. Published by N. V. Philips' Gloeilampenfabrieken, Eindhoven-Netherlands,* $2.15.

In modern control and logic systems, an electronic switching circuit, known as the bistable multivibrator or "Eccles-Jordan flip-flop," has found widespread application. Equipment with which this circuit is used includes electronic counting and computing devices, time-measuring apparatus, telemetering and automatic remote-control systems. This book gives a thorough analysis of the dynamic behavior of the bistable multivibrator.

Acoustical Engineering

HARRY F. OLSON, PH.D, *Director, Acoustical and Electromechanical Research Laboratory, RCA Laboratories, 6½ x 9¼ in., 718 pp. Published by D. Van Nostrand Co., Inc., Princeton, N. J.* $13.50.

The momentous strides of modern acoustic science in recent years are reflected in this new and greatly enlarged third edition. From fundamentals to practical applications, it now presents complete working methods covering the entire field of acoustical engineering.

In all areas covered, rapid advances have made much new material and many revisions necessary. Two large chapters dealing with complete sound reproducing and communications systems have been added. Included among the most recent developments described are: in underwater acoustics, systems for detecting and locating crafts and obstacles, and for depth soundings; in ultrasonics, industrial techniques for cleaning machined parts, for drilling and detecting flaws; in architecture, methods of obtaining excellent acoustics under severe artistic considerations; in music, new musical instruments.

Throughout the book, consistent and logical use of analogies between electrical, mechanical and acoustical

(Continued on page 180)

here's graphic PROOF of the HIGHER WATTS DENSITY in WATLOW

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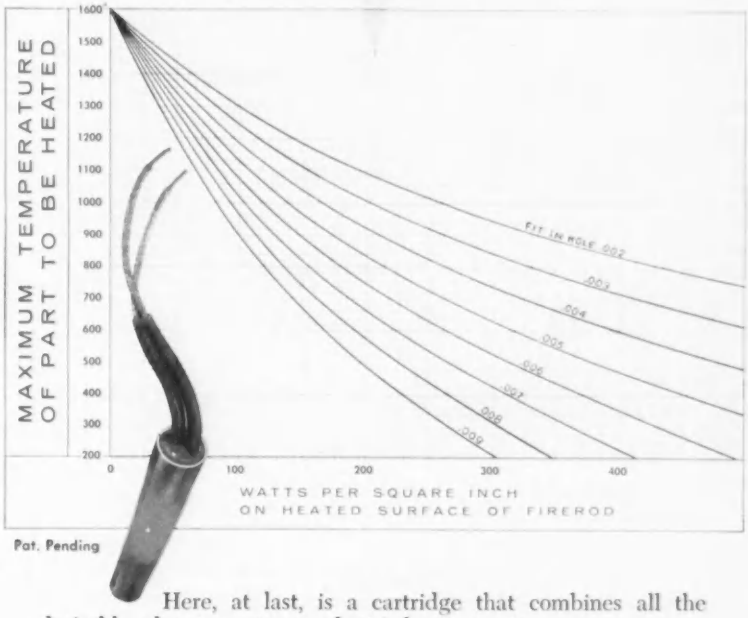
CARTRIDGE HEATERS



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No electroplating--no mechanical finishing!

TREATED WITH NEW IRIDITE

NEW IRIDITE® (Cast-Zinc-Brite)

brightens zinc die castings by chemical polishing, protects against corrosion

NOW, FOR THE FIRST TIME you can get a brilliant, decorative finish directly on zinc die-cast parts . . . without mechanical finishing, without electroplating! The luster is provided by the *chemical polishing* action of new Iridite (Cast-Zinc-Brite) solution. Even surface blemishes, such as cold shuts, are brightened by this new process. No electrolysis. No special equipment. No specially trained personnel. Just a simple chemical dip for a few seconds and the job is done. And, this new Iridite has been *tested and proved* in production.

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systems is made because reduction of a vibrating system to the analogous electrical network has been found a valuable tool in its analysis. Detailed presentations of theory and practice are given for all important transducers. The material on speech, music and hearing correlates objective and subjective acoustics. As an aid in development and design, a large number of useful formulas, tables and graphs are included, as well as acoustical elements, radiating systems and mechanical vibrating systems.

The Elastic Constants in Structural Design With Particular Application To Titanium

S. A. GORDON, 8½ x 11 *in.*, 30 *pp, paper bound. Available from Office of Technical Services, US Department of Commerce, Washington 25, D.C.* $1.

The elastic constants of materials and their application to design formulas are discussed. Studies are presented to show the effect of variations in these constants on the formulas in which they are used. Typical design curves are presented for titanium and 17-7PH for columns, buckling, and crippling of open sections, and torsion in cylinders. An analysis is also presented of several typical beams and columns to show the effect of the modulus of elasticity of titanium and 17-7PH on the over-all deflection of structures. The basic developments are reported so that additional design curves can be plotted for different elastic constants or materials of different strengths.

In reviewing the application of the elastic constants in design, the following points appear to be worthy of consideration:

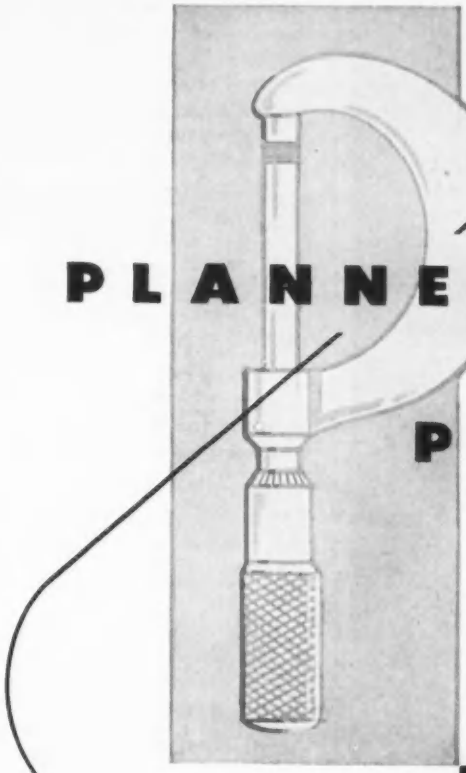
(1) Poisson's ratio of a material can be approximated with reasonable security, since large differences in the value reflect themselves only in small errors in design. A value of $.35 appears to be a good compromise, since μ increases in the plastic range.

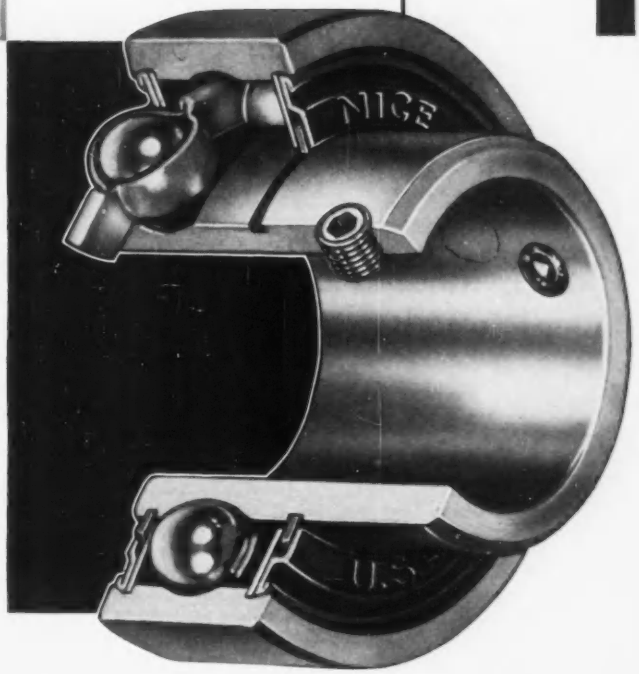
(2) Reasonable errors in the modulus of elasticity can be tolerated in design formulas, particularly in the high stress ranges.

(3) Using a material of high modulus does not necessarily mean that the structure designed from this ma-

(Continued on page 182)

PLANNED PRECISION





In a bearing, PLANNED PRECISION is the carefully evaluated incorporation of whatever precision features are necessary to provide for the functional requirements of the job—not more, not less. Precision refinements are costly, and should be selected with care to insure products that are both economically and functionally correct.

In the NICE LINE, Product Designers will find a complete range of ball bearings incorporating varying degrees of precision. NICE catalog standard bearings are available in precision, semi-precision and unground types. If a specially designed bearing is the correct answer to the application problem, NICE engineers are qualified and capable "Specialists in Specials".

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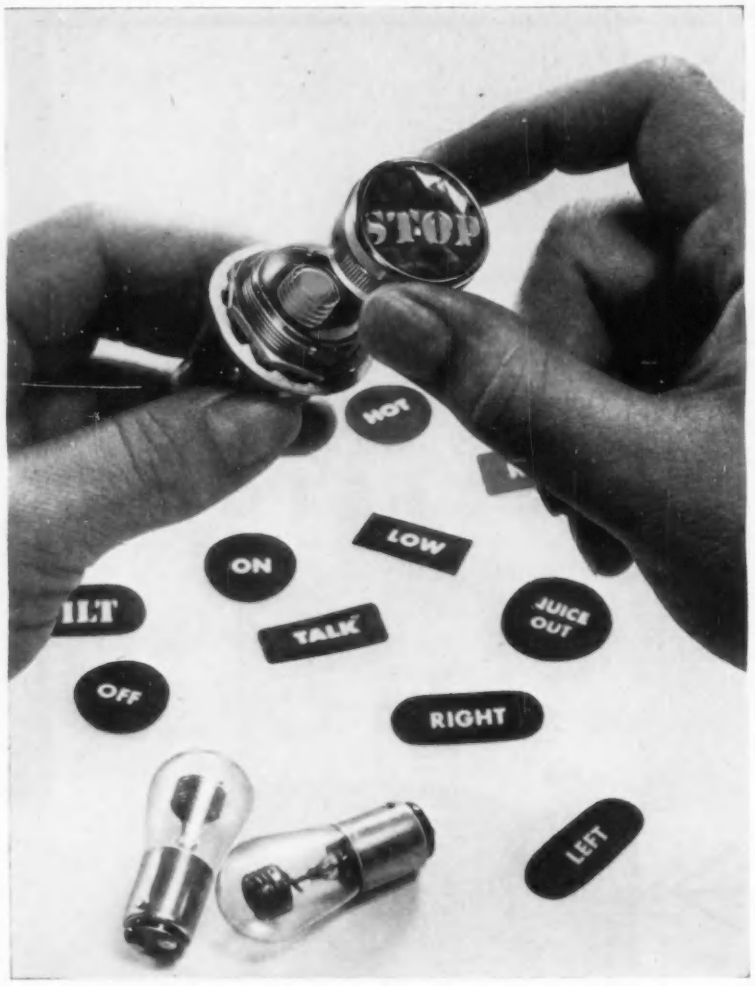

New G-E Indicator Lamp "lives" 10,000 hours ... resists shock and vibration ... needs no transformer

The light output of the new General Electric Glow Lamp, NE-79 is easily sufficient to illuminate the legend in a cover glass or lenses in a diversified array of indicators. Made for use on 105-125 volt circuits, in series with a 1 watt 7500 ohm resistor, no transformer is needed. Since the bulb is only 3/8" in diameter it fits pilot assemblies which go into a 1" mounting hole.

The NE-79 has inherent resistance to both shock and vibration and, since it is equipped with a double contact bayonet base, it cannot shake loose in the socket. For further information on the NE-79 glow lamp write to General Electric Company, Miniature Lamp Department PE-117, Nela Park, Cleveland 12, Ohio.

Other General Electric Glow Lamps have electrical characteristics that let them serve as relaxation oscillator, leakage indicators, switches, voltage regulators, or voltage indicators.

Progress Is Our Most Important Product

GENERAL ELECTRIC

terial will be more rigid than one designed using a material of lower modulus.

(4) The answer to the amount of weight that can be saved as predicted by the structural index approach is not complete. Once the material is chosen, careful selection of efficient configurations are required to utilize fully the weight saving anticipated. Even so, it may not always be attained if proper consideration is not given to the criteria of design in early stages of material selection.

Devices for Damping Mechanical Vibrations

Compiled by MILDRED BENTON, 8 *x* 10½ *in., 94 pp, paper bound. Available from Office of Technical Services, US Department of Commerce, Washington 25, D.C.* $2.75.

Vibration damping is the reduction of the response of a mechanical system to a vibratory force. This is done by increasing the mechanical impedance of the system, by energy dissipation, or by tuned attachments. The term is also applied to vibration isolation, which is the reduction in efficiency of vibration energy transmission by changing mechanical impedance. Energy dissipation can be increased by (1) vibration dampers, (2) connection damping, (3) material damping.

This bibliography, covering the period 1924—August 1956, includes references to periodical articles and technical report literature that offer information in damping devices within the field of reference outlined above. They were selected by a systematic search of numerous sources. Chronological references are listed by author. An author index and a subject index are also included.

Introduction to Printed Circuits

ROBERT L. SWIGGETT, *Photocircuits Corp., 5½ x 8½ in., 101 pp, paperbound. Published by John F. Rider Publisher, Inc., 480 Canal St., New York City.* $2.70.

Each of the printed circuits used in electronic equipment today is described, along with its characteristics

(Continued on page 184)

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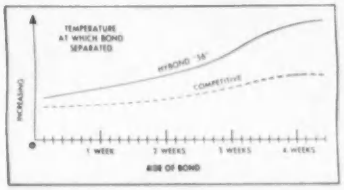
SINCE 1884

ADHESIVE DIGEST

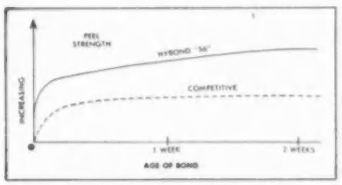
LATEST DEVELOPMENTS IN ADHESIVES FOR INDUSTRY

COMPARATIVE ANALYSIS



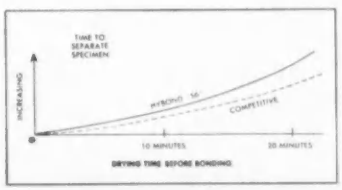
HEAT RESISTANCE

Plastic laminate bonded to wood. Specimen placed in oven under dead load in shear. Temperature increased at constant rate until separation occurs. HYBOND "56" provides greater resistance to surface heats and the high storage temperature to which many finished products are subjected.



PEEL STRENGTH

Fabric-backed linoleum to steel. Peel strength determined on Scott tester. This chart demonstrates HYBOND's greater peel strength. At the end of two weeks the strength of the bond is greater than that of the linoleum.



RESISTANCE TO DEAD LOAD

Fabric-backed linoleum bonded to steel. Specimen 1" wide subjected to dead load immediately after bonding. Demonstrates HYBOND's ability to offer greater resistance to "fight" of surfacing materials when required to conform to contour.

MASS PRODUCTION LAMINATING MADE POSSIBLE BY NEW CONTACT ADHESIVES

Thanks to latest developments in the field of chemical bonding, mass production techniques now prevail in more and more industrial laminating operations. Inseparable in this trend are *sprayable* contact adhesives which provide fast drying, instantaneous bonds. In consequence, these features eliminate the need for clamps, presses and complicated heat-curing schedules which retard production and increase cost burdens.

Typical of these highly-functional, time-saving adhesives is HYBOND "56" recently introduced by Pierce & Stevens Chemical Corp. HYBOND "56" is a fast-setting, *sprayable*, synthetic rubber adhesive designed especially for high-speed production schedules involving the bonding of a wide variety of dissimilar materials — plastic laminates, plywood, steel, aluminum, fibreboard, rubber, leather, fabric, paper honeycomb, etc. HYBOND "56" has proven particularly effective in the mass production bonding of counter and desk tops, porcelainized metal chalk boards, honeycomb partitions, "curtain-walls" and trailer bodies.

HYBOND "56" symbolizes progress in contact adhesives — offers these real advantages:

Greater peel strength — in laboratory and field tests of linoleum bonds to metal, the linoleum ruptures while the bond persists.

Higher heat resistance — provides a greater safety factor when bonded products are exposed to high temperatures.

Greater dead-load strength — yet sufficiently elastic to resist shock and fatigue.

HYBOND "56" is spray-applied — dries within minutes to the tacky condition required for bonding — adheres instantly when the cemented surfaces are joined. The final bond is odorless, non-staining and highly resistant to moisture, oil, grease and many chemicals.

Complete technical data on HYBOND "56" may be obtained by mailing the handy coupon. No obligation, of course.

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Please send complete technical data on HYBOND "56". Also send copy of comprehensive P&S Product Catalog as illustrated at left.

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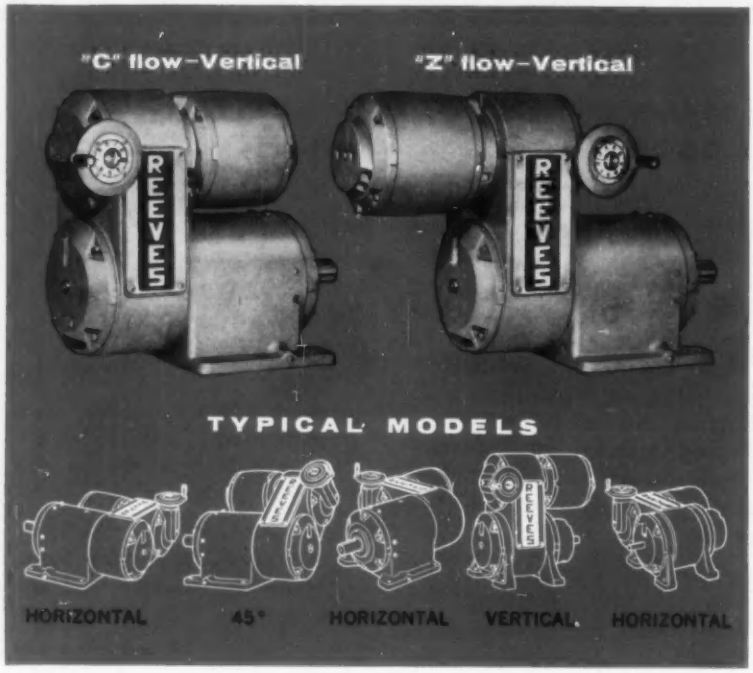
**200-300 Size, 1 through 5 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

New increased capacity is built in the reducers—single, double or triple stages . . . new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

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REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

and functions, manufacture and effect on service techniques. The purpose of this book is to provide the engineer, serviceman or technician with a broad knowledge of the printed circuit field.

Subjects included are: ceramic-based circuits; etched, plated, embossed, stamped, and other phenolic-based circuits; components for printed circuits; assembly systems, and servicing of these circuits.

Handbook of Linear Transducers

Published by Automatic Timing & Controls, Inc., King of Prussia, Pa. 8¾ x 11 in., 32 pp, plastic-bound. $2.

This handbook provides theory and application data for differential transformers. Characteristics of various differential transformers and basic circuits are described, tabulated and charted. 15 typical applications are included.

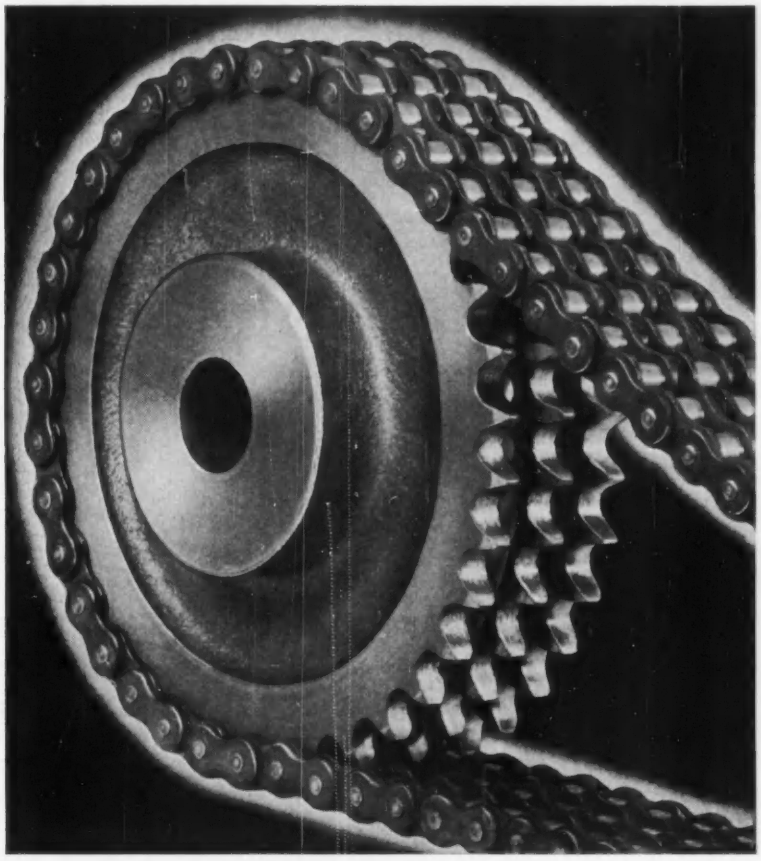
Introduction to Electrical Applied Physics

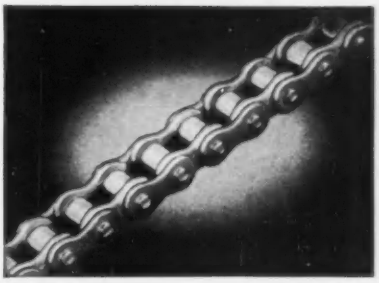
N. F. ASTBURY, 5¾ x 9 *in.*, 241 *pp. Published by Philosophical Library, Inc.*, 15 E. 40*th St.*, New York 16, N. Y. $10.

During the past 25 years, electrical science has developed a new subject that is neither physics nor engineering of the ordinary type. In addition to new work, it involves revived interest in and applications of earlier works

(Continued on page 187)

"Oh . . . Hello, Farnsworth . . . Here are a few things I borrowed while you were on vacation."





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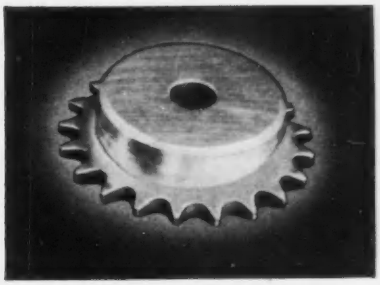

ATLAS *Balanced* SPROCKETS

Precision made to exact chain fit. Available in all sizes 3/8" pitch to 2" pitch . . . steel, stainless steel, bronze or Atlas Electrolized for longer life.

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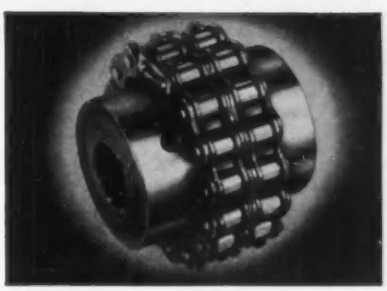
Atlas Roller Chain, Sprockets and Flexible Couplings are precision matched to operate as a power team for peak efficiency. They are made to run quieter, last longer and require less maintenance. They are a *power team* to provide higher efficiency and longer life on every type of installation.

ATLAS CHAIN AND MANUFACTURING CO., P.O. Box 708, West Pittston, Penna.



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SILENT-LIGN PILLOW BLOCKS for shaft mounting. Has all Flexible Bearing features.

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that had seemed to be only of academic interest.

This book brings together the classical basis of the subject and the elements of some specialist topics, which, by the natural processes of technological evolution, are finding their way into all fields of applied science. Principles, rather than techniques, are stressed.

Subjects discussed include: the physical basis of the subject, electrical and magnetic fields and circuits, electromechanical and electro-acoustical systems, electron devices (tubes, transistors, photosensitive devices), and electromagnetic waves and radiation. Rationalized M.K.S. units are used throughout.

Manual of Mathematics

No. 781, 6¾ x 3¾ in., 334 pp, looseleaf-bound, tabbed index. Published by Lefax, Ninth and Sansom Sts., Philadelphia 7, Pa. $4.25.

The looseleaf manual includes the following subjects: Mathematic Reviews, Logarithmic Tables, Natural Trigonometric Functions, Conversion Tables and Functions of Numbers. A handy reference text in easy-to-use form for commonly used equations, functions and tables.

Additional data sheets may be included and blank pages inserted for notes or comments.

Foamed Silicone and Polyester Sandwich Cores

V. C. Setterholm and E. W. Kuenzi, *Forest Products Laboratory for WADC, PB 121707, 8½x10½ in., 25 pp, paperbound. Available from US Dept. of Commerce, Office of Technical Services, Washington 25, D.C. $0.75.*

This report covers compression, tension and shear tests made at temperatures from 75F to 700 F on plastic sandwich with foamed-in-place cores. Included are silicone cores of Dow Corning silicone resin R-7002, foamed to eight densities from 12.6 to 17.5 lb per cu ft, and a triallylcyanurate-modified polyester resin, Laminac 4231, reacted with two, four-toluene di-isocyanate and foamed to densities of 11.9 and 12.2 lb per cu ft.

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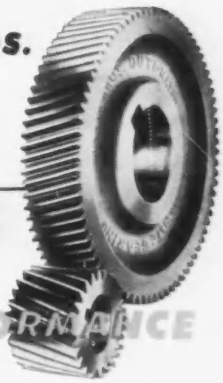
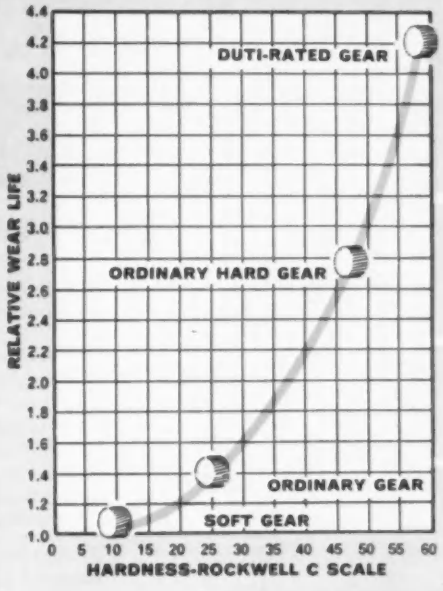


GEAR PERFORMANCE COMPARISON CHART



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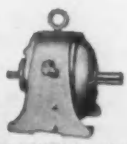
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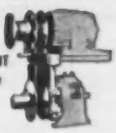
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Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

Make Salaries Known

To The Editor:

I was intrigued by the letter "The Salary Problem" (Oct. 14 '57, p. 195) from Mr. John D. Kemper of Marchant Calculators, Inc. Among other things, Mr. Kemper decried the psychological effects on engineers which resulted from publishing salary curves. He proposed that salary curves be kept confidential for management use only. The inference here is that when management has the facts they will take care of the engineers' welfare and the engineer need not concern himself with these matters. This is another restatement of the age-old cry, "Let the engineer worry about his work and management worry about his welfare and everything will work out fine" (for management).

I strongly object to this philosophy as not being in the best interests of either the engineering profession or its employers. In the first place, one of the most satisfying things to me about the salary structure of our profession is the tremendous salary differential, which exists between the lowest-paid engineer at a certain experience level and the highest-paid engineer at the same experience level. Some people view this differential as being an appropriate evaluation of the different contributions made by different engineers. I view it in an entirely different light. I view it as a continuous incentive for each engineer to work harder and do higher-quality work. Obviously, the salary differentials have zero value as incentives unless the engineers are aware that these differentials exist. When an engineer who is making $600 per month has concrete evidence that his own employer is paying engineers, at the same experience level, up to $900 a month and is content to pay others as low as $400 per month, he can translate this directly into the quantitative difference his own real incentive. The old saying, "The sky

(Continued on page 193)

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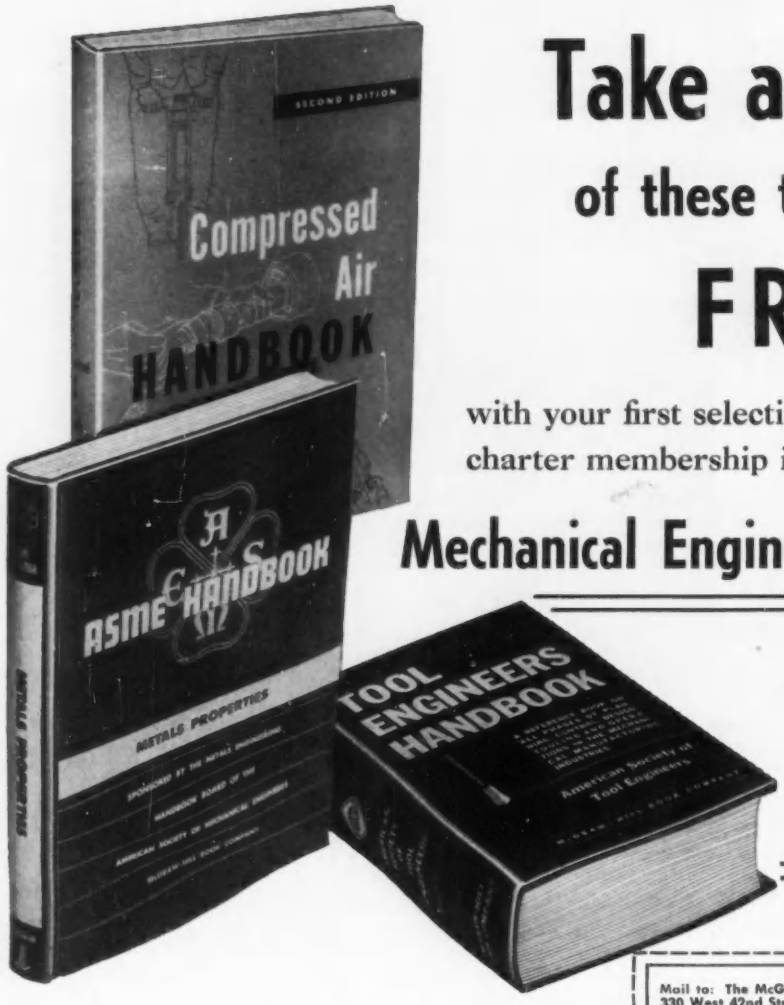

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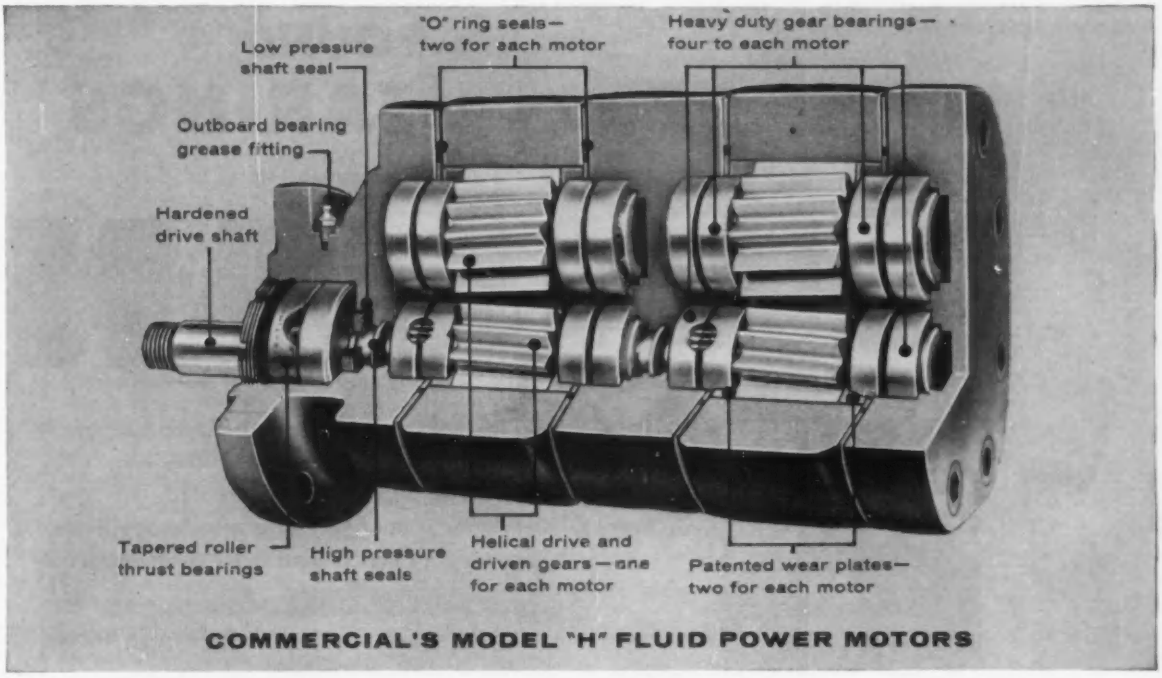

COMMERCIAL'S MODEL "H" FLUID POWER MOTORS

New ideas in fluid power motors

Multiple-speed drive simplified

Efficient operation of heavy mobile equipment frequently involves multiple speeds. Not so efficient, however, is the shifting of gears, the power take-offs, clutches and gear transmissions involved in gaining these desired speed levels with mechanical drives—not to mention the constant maintenance headaches these same drives entail.

Pictured above is one Commercial fluid power oil-hydraulic motor that now delivers low and high speeds efficiently—completely eliminates the problems mechanical drives ordinarily involve.

Two motors work in tandem

This Commercial Model "H" tandem motor actually involves two single motors of equal output mounted on one common drive shaft. When fluid power from the pump source is directed by simple valving into just one of the single motors, the shaft rotates at the high speed. The other single motor on the same shaft receives no input and therefore merely turns. When low speed is required, the total fluid power delivery from the pump is valved into both of the single motors. And of course motor torque at this reduced speed is doubled. This simplified control of two speeds—both low and high—is possible in either direction, forward or backward.

Each of the single motors in this Model "H" tandem motor has one-inch gears. With a fluid power input of about 15 gpm at 1200 psi, for example, when one of the single motors receives the entire input, rotation is 1200 rpm. When the same input is split between the two equal size single motors, rotation is 600 rpm.

Model "H" motors are available with gears in widths of 1", 1¼", 1½", 2", 2½" and 3". Any combination of gear sizes is practical.

More than two speeds

Even three speed operation can be obtained with Commercial double tandem motors when gears of different widths are used in each single motor. High speed operation results when the full pump delivery is valved to the motor with the smaller gears, intermediate speed when it is all directed to the larger gear motor, and slow speed when valved to both motors. One single motor having three-inch gears operating at 1600 psi at a speed of 1200 rpm would develop about 50 h.p. Commercial Model "H" motors are recommended for continuous duty operation at pressures up to 2000 psi and speeds up to 1800 rpm.

Engineering help available

Be sure to send for your copy of Commercial's "Oil-Hydraulic Motors Catalog H-4". Further information on Commercial's complete line of other fluid power components—valves, pumps and cylinders—is also yours for the asking, as is technical help and assistance from Commercial on fluid power applications.

Address inquiries to The Commercial Shearing and Stamping Company, Dept. G-48, Youngstown 1, Ohio.

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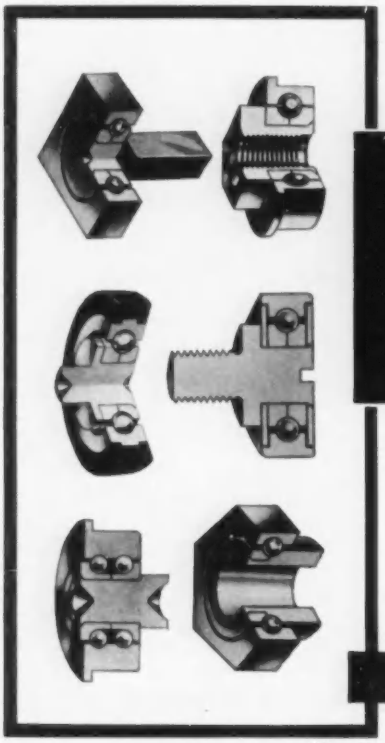

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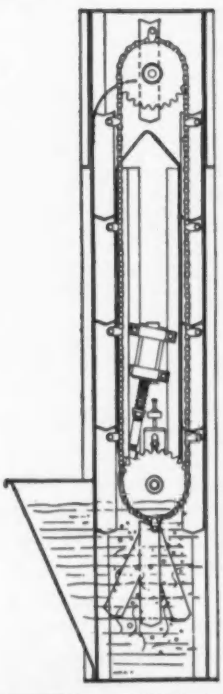

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is the limit. Work real hard and you will earn more money" is not an incentive.

Mr. Kemper, however, does have a point. Since engineers have not yet become accustomed to thinking of themselves in terms of their position in a salary spectrum, many engineers are needlessly upset when they discover that their salary places them in the, say, lower decile. There are, however, two solutions to the "a little knowledge is a dangerous thing" problem. Mr. Kemper favors the elimination of that "little knowledge." I favor the extension of that "little knowledge" into a complete understanding.

Although we cannot measure them with precision, we do know that there are substantial salary differentials which do exist between various employers of engineers, even for engineers whose abilities and responsibilities do not differ. These differentials were created and maintained in an environment in which management was aware of the differentials. This was precisely the environment which Mr. Kemper now proposes to re-establish. Since he proposes no different solution to the problem of differentials we presume that he would be satisfied if such inequities were to continue indefinitely. I am unable to see how any true friend of the engineering profession could fail to be distressed by differentials based on anything except ability and responsibility.

It is well to keep in mind that ignorance is an absolute prerequisite to the perpetuation of unwarranted salary inequities. I therefore suspect that any person who favors ignorance is quite likely also to favor the continuation of unwarranted inequities.

—Joseph Amann
President
Engineers and Scientists of America

Who Should Be Called an Engineer?

To The Editor:

Commenting on your editorial in the Sept. 30 issue (p. 69), it seems to me that many of our present difficulties are in considerable measure due to the conferring of "Industrial Degrees" where job titles having a professional flavor have been adopted. Strictly speaking, a man is an M.E.,

(Continued on page 194)

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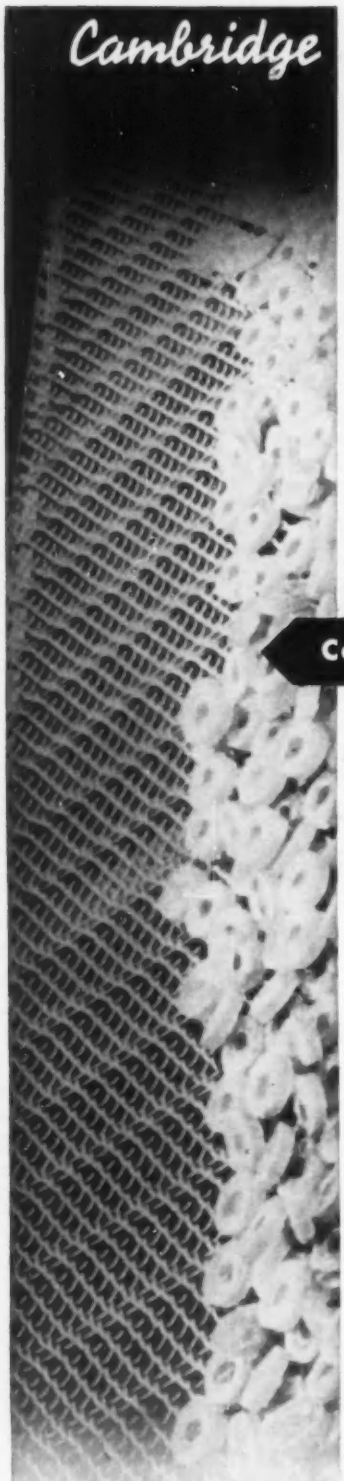

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Fifty years ago, most men who held the company title of "Chief Engineer" were graduate engineers. Since then, the custom of using the word "Engineer" as a job title instead of evidence of professional competence has become widesperad partly through ignorance and partly through the desires of smaller men to assume dignities, to which they are not entitled. This same element of jealousy led to the general abandonment of such designations as M.E. or E.E. on business and personal cards; because it was considered to be "high hat" and "Un-American." The same "practical men" were delighted to accept honorary degrees regardless of who conferred them.

When I was sent to South America a few years ago, I was surprised when told that my card should carry the initials indicating my educational achievements, and that since I was an M.E. and not a B.S., I would be introduced as "Doctor" and should expect and insist on being addressed as "Doctor," particularly by my associates and subordinates.

With respect to Engineering Registration, as covered by the various state laws, it shows some glaring inconsistencies. One group wishes to use it as a super union, others as evidence of professional competance. In some states, the courts have severely limited its use to fields of public interest and in none is it required in private business. Some states use the system to attempt to reserve work for men registered in that state. Ohio has limited the using of the word "Engineer" by any one not registered. At least they have eliminated use of the term: "Heating Engineer." Examinations as a means of certifying the competence of the self-educated man would be a valuable service. As a system of local labor monopoly it reduces the engineer to the status of a barber.

With reference to engineering unity, the subject of your editorial, no improvement will come until the engineers themselves recognize and respect each other's education and profes-

(Contiued on page 197)

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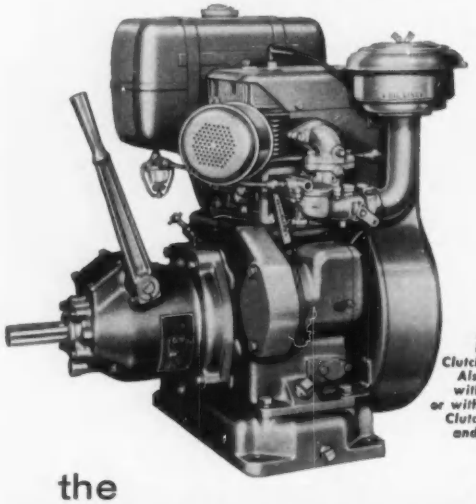

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sional competence regardless of the size of the pay check. No organization or group of organizations can do this for them. —FRANK MARINDELL
Chief Engineer,
Ferracute Machine Co.

What Is an Engineer?

To The Editor:

In the Oct. 21 issue Mr. Albert Damelio asks, "What Is an Engineer?" Perhaps he will accept one or more of the following:

1. An engineer is a mechanical genius who refuses to recognize his own ideas when confronted with them on paper.

2. An engineer is a person who passes as an exacting expert on the basis of being able to turn out with prolific fortitude infinite strings of incomprehensible formulas calculated with micrometric precision from vague assumptions which are based on debatable figures taken from inconclusive experiments carried out with instruments of problematical accuracy by persons of doubtful reliability and questionable mentality for the avowed purpose of annoying and confounding a hopeless chimerical group of fanatics referred to all too frequently as engineers.

3. An engineer is a man who can do what he wants with what he's got.

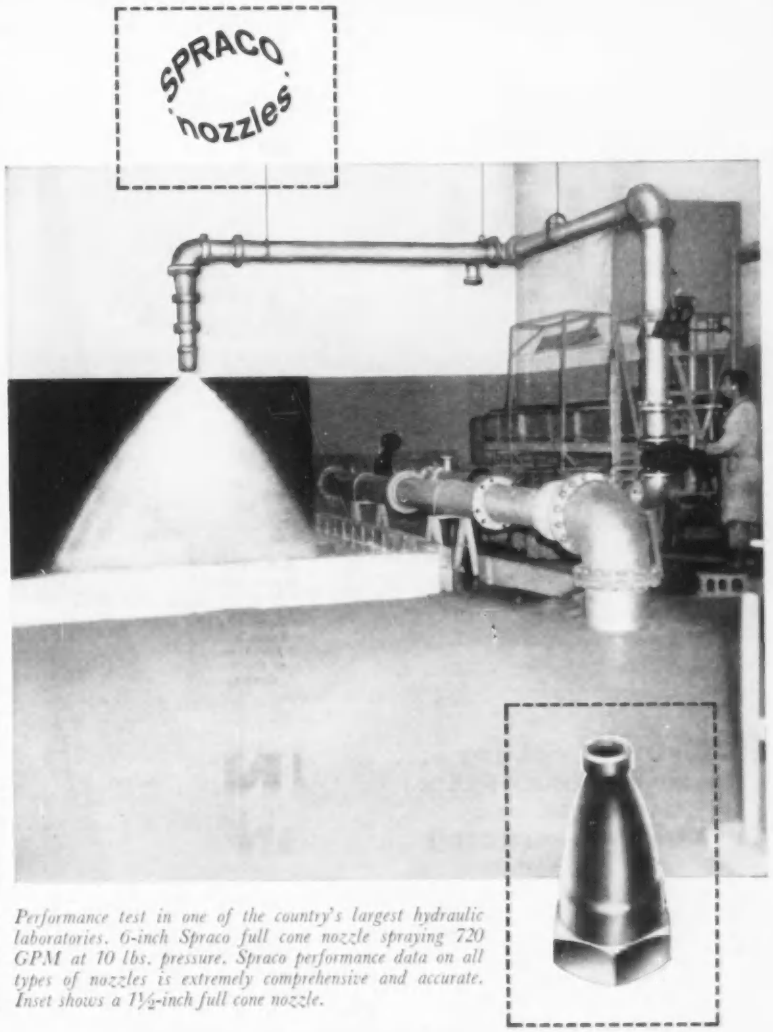
4. An engineer is a man who can do with one dollar what any d--n fool can do with two.

5. He who works with his hands is a laborer; he who works with his hands and his head is an artisan; but he who works with his hands, his head, and his heart is an engineer.

6. The engineer is, by aptitude and training, a creative person who is able to generate solutions to problems that most times are unique and apparently insoluble. In so doing, he must often conduct research and experimentation on new and unproven ideas, materials and techniques. As a result, the value of the engineer cannot be measured by salary, seniority, rank or other such trivial criterion, but rather by this ability to generate ideas, conduct experiments, invent new devices, and efficiently utilize the materials and techniques available to him.

Unfortunately, I have not kept a

(Continued on page 198)



Performance test in one of the country's largest hydraulic laboratories. 6-inch Spraco full cone nozzle spraying 720 GPM at 10 lbs. pressure. Spraco performance data on all types of nozzles is extremely comprehensive and accurate. Inset shows a 1½-inch full cone nozzle.

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IN STOCK — the most complete range of sizes and capacities available anywhere.

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*Pat. App. For

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record of the sources of each of the above so no credits can be given. My apologies to each of the originators. As to a motto for engineers, I suggest, from Goethe,

**"If the hand and eye you deftly train,
Firm grows the will and keen the brain."**

—M. M. EARLE
Chief Naval Architect

To The Editor:

Mr. Damelio requested a definition of an Engineer (Oct. 21, p. 54). We submit the answer that a "professional engineer is a licensed engineer". Since more than one-third of the engineers in the country are registered, it is no longer debatable as to whether registration is necessary. We do not believe registration was necessary for engineers whose employers took the responsibility to the public for the product, but a majority believe registration is necessary for professional recognition and advancement of the profession.

The National Society of Professional Engineers has grown from 8,000 to 42,000 qualified, licensed, professional engineers in the past 13 years. We suggest Mr. Damelio join us and resolve his dilemma of how to recognize an engineer.

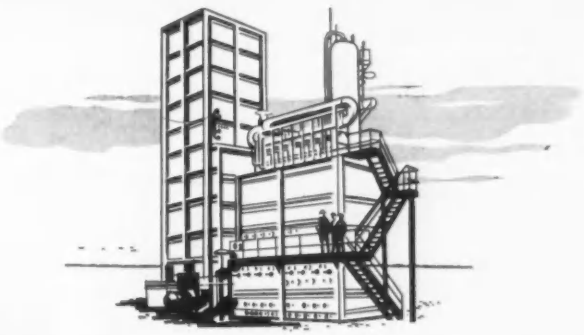
—PHILIP C. ROSS, P.E.
Chmn. Engineer-In-Industry Committee
New York State Society of Professional Engineers

Let's Educate the Public

To The Editor:

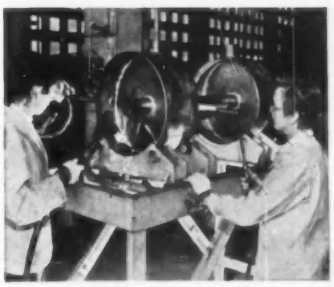
"It's what we do next that counts." (Oct. 21, p. 17). This is true but what we do next depends on what the American people demand. We, the general public can, if we will, dictate the actions of our government. We are a vast group of people with heads full of scientific misconceptions. Such general ignorance is responsible for placing our scientists in a class of weird people to be mistrusted and have their warnings taken lightly. If the American public is so complacent and unmoved it's not surprising that the administration and the government that represents the people are also complacent. As your editorial brought out, it won't be long before

(Continued on page 201)



JOIN WITH HANDY & HARMAN SILVER BRAZING FOR PERMANENT PROFIT

Joining Heat-Exchanger Tubing To a Header Ring: Brazing team joins 78 closely spaced tubes to header ring of heat exchanger. Degreasing and fluxing with Handy Flux takes place before assembly. EASY-FLO 35 is hand-fed; heating is oxy-acetylene. Two operators braze complete assembly in 35 minutes.



Brazing Tube Sheet Into Sleeve: Involves a hermetic joint between ¾ in. thick copper tube sheet and the inside wall of a copper-bronze sleeve. Operators work as a team, one face-feeding the EASY-FLO 35 wire from the front, partner heats from the back to draw molten alloy through. On some units joint is 1½ in. thick, 170 in. in circumference. Average time 30 minutes per joint.

How would *you* make 300 joints involving 6 different metals?

Air Products, Inc., Allentown, Pa., does it with silver brazing

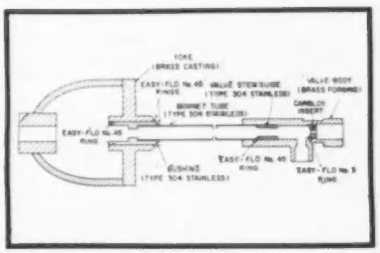
Here you have an air separator that produces tonnage quantities of oxygen and/or nitrogen for industrial uses. Its components are made of Type 304 stainless steel, cast bronze, brass, copper, copper bronze and Carboloy. Joints range in size from less than ¼ inch to 54 inches in diameter. Metal thicknesses vary from .025 to 1½ inch. In operation, the separator is exposed to temperatures of −300°F and pressures approaching 5000 psi.

Complex? You said it and when you take *everything* into consideration – range of metals, operating strength, metal thickness, joint sizes, production speed and economy – Handy & Harman silver alloy brazing is the *best* way to do it.

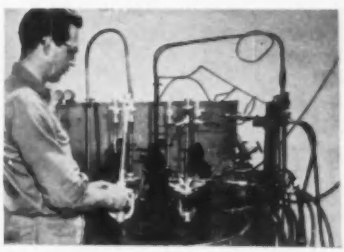
Air Products handles these multiple production problems with speed and dispatch. Illustrated are three examples.

This operation typifies the versatility of Handy & Harman silver alloy brazing. Here is one method doing a *wide variety of jobs*. It is doubtful whether any other existing method could be used to the same effect on an *assembly line basis*. It can do as much for you.

Look into Handy & Harman silver brazing. We'll work closely with you.



Six-Piece Expansion Valve Assembly Joined In One Operation: Drawing of valve assembly shows locations of 5 preplaced rings of EASY-FLO 3 and EASY-FLO 45. Rotary table silver brazes about 20 expansion valves an hour, more than three times the former rate with hand torches. Multiple burners are used to reduce heating time for the heavy brass parts. Burners can be repositioned and more burner stations added.



Bulletin 20, to begin with

This concise bulletin introduces you to silver alloy brazing—gives joining methods and joint design as well as economies that exist with EASY-FLO brazing. Just ask, we'll be pleased to send you a copy.

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In its more than 30 years' history, Sandsteel has developed many tools and dies that are adaptable to various types of power spring manufacturing.

The presence of this equipment cuts down the tooling costs to the customer when Sandsteel handles the job.

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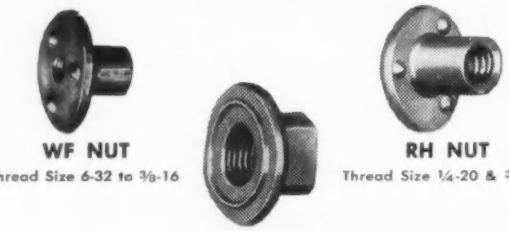
THE PRIMARY FASTENERS IN FASTENER ASSEMBLIES



WF NUT
Thread Size 6-32 to 3/8-16

SF NUT
Thread Size 5/16-18 to 1/2-13

RH NUT
Thread Size 1/4-20 & 3/8-16

OHIO flanged weld nuts provide extra-long thread engagement and are ideal for assemblies requiring strong primary fasteners. They can also serve as spacers or bearing surfaces where required.

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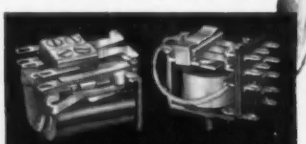

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the excitement of Sputnik will die down. The headlines will scream of some other event, and TV comics will joke about whatever comes along next. Nothing will be done.

How can this be prevented? Simply by educating the public. Our freedom to educate is a powerful tool against Communism and should be used. We must be put on the right track and educated through the means that have misinformed us; the newspapers, popular magazines and TV. This is where industry and science should do their part and plead their case.

If scientists were today's celebrities, people would be more aware of the fact that they aren't weird people to be mistrusted. I'm not suggesting that we change the entire content of the news. I'm only saying people should be made aware of the scientific world in the same way they are of some female's measurements or some man's bank account.

I'm sure that if the American public knew the facts and really understood the scientific world they would back research and make the national government also get behind it. It's up to industry and informed people to get the truth before the American people.

—Audrey Ingelse
Phoenix, Ariz.

Lignum Vitae Bearings

To the Editor:

Mr. Stanley Abramovitz' article, "Water-lubricated Fluid Bearings Are Practical" (Sept. 30, p. 74), was very interesting to me. But I do not believe Mr. Abramovitz would have used the word "practical" if he had visited shipyards and had seen outboard propeller bearings 6 to 30 in. or more in dia being refitted with lignum vitae wood.

Lignum vitae has been used for at least a hundred years or more for bearing material where the lubricant is water. And in all cases where there is no abrasive in the water, it has given very satisfactory service.

Also, Mr. Abramovitz did not give credit to Dr. Kingsbury who invented and patented the pivoted-pad thrust bearing.

I know of no large, powered ship

(Continued on page 203)

This rotary switch component for an electric range proved to be a delayed-action saboteur. The beryllium copper from which it was formed was so hard that over a period of time it scratched and gouged the phenolic cams actuating the switch—to the point where the switch would soon become inoperative, causing customer complaints and damaging the manufacturer's reputation.

A specially-produced phosphor bronze alloy from Miller provided a quick and painless solution. Miller experts were able to recommend and produce a metal that retained the high degree of spring tension necessary for dependable operation—yet soft enough to protect the cams from damage. And, as an *extra* benefit, the manufacturer also found that it formed more easily—with far fewer rejects.

Miller *specializes* in the expert production of quality phosphor bronze—in strip, coiled and flat lengths—tailored to your specific needs. Remember: at Miller, Phosphor Bronze is the main line—*not* a sideline.

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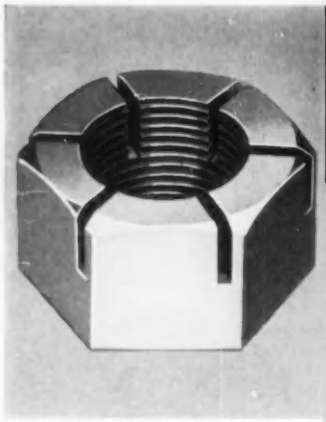
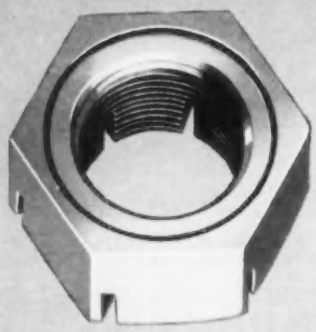
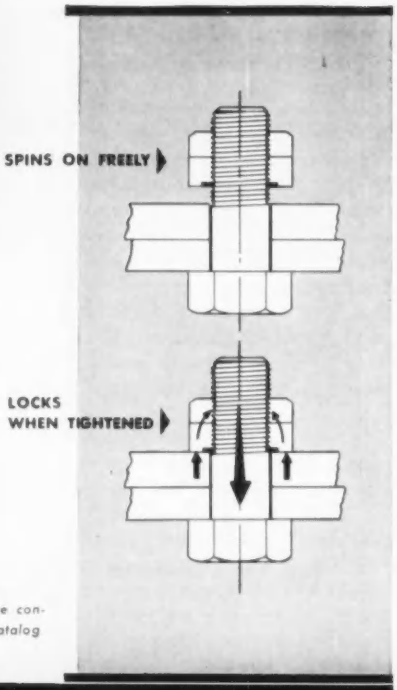
America's Quality Phosphor Bronze



the
MARSDEN
free running lock nut





The Marsden action can be incorporated into nuts of any size or material, with standard or special threads—its action relieves the heavy concentration of stress in the lower threads of a conventional nut.

Manufacturer of Standard and Special 12 Pointer and Hexagon Nuts . . . "Huglock" and "Marsden" locknuts.

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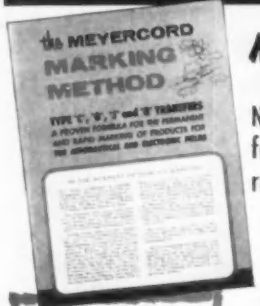

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Heat . . . abrasion . . . weather and many of the new surfaces are deadly enemies of most types of product markings. But not to the new improved Meyercord Markings, Types C, G, J and H (heat resistant). Depending upon the surface and the conditions of use one of these new-type Meyercord Markings will, by actual test, almost certainly solve the problem. For exact recommendations designed to meet your special requirements, drop us a note outlining the problem, along with an actual sample of the surface. This service is offered without obligation of any kind.

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- . . . reduced starting friction by factor of 5 in miniature precision ball bearings. (Field Report 32)
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- . . . allowed load increase from 3 H.P. to 5 H.P. on worm gears of single reduction speed reducers. (Field Report 24-41)
- . . . increased cycles from 28,000 to 700,000 in tests on brass taper air valves. (Field Report 4)
- . . . raised Oilite bearing life from 6 to 46 hours. (Field Report 24-47)
- . . . raised life to failure time from 120 to 400 hours on sintered bronze bearings; reduced wear in 12 hour test from .002 to .001. (Field Report 43)

MOLYKOTE Field Reports are filled with thousands of these case histories. Write for your copies . . . but be sure to mention your application.

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that does not use the Kingsbury thrust bearings with wonderful success.

Therefore, the article, "Water-lubricated Fluid Bearings Are Practical," is a little out of date for me.

—MILO C. CAUGHREAN
San Francisco

ED.—In his original manuscript Mr. Abramovitz included a drawing of a 30-in. lignum vitae bearing plus a description of its properties. Severe space limitations, and the conviction that this description would contribute little that is new to the current literature, convinced us that it might be left out without impairing the author's contribution. The fact that lignum vitae has long been used in ship building was mentioned in "Interesting to Note" (Sept. 30, p. 7). It is one of our hardest woods.

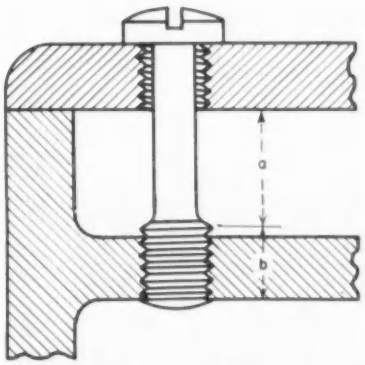
Dr. Kingsbury did invent the tilting-pad design shortly after the turn of the century. However, A. G. M. Michell invented the same bearing at the same time in Great Britain and today both men are credited with the discovery.

Impossible Fasteners

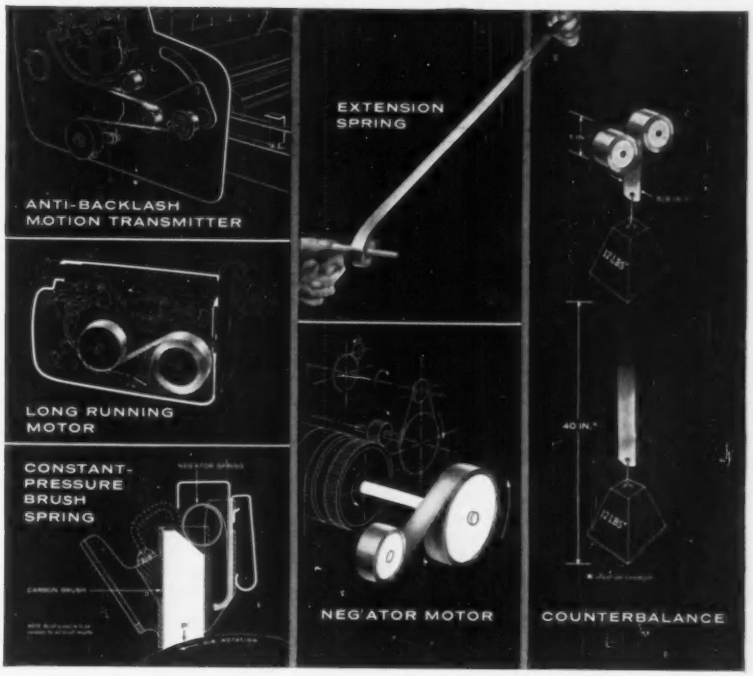
To The Editor:

In the July issue, p. 177, are listed several illustrations of tamper-proof fasteners. Illustration A, Figure 5, is impractical as there are two threaded positions on the screw. The reduced shank should extend to the head of the screw to enable a tight fit of the cover to the casting. The cover would remain tapped of course.

STEPHEN GERYLO
Cardinal Heights, Ontario



Ed.—Mr. Gerylo is right. Here is how it should have looked.



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Its use in instrumentation is growing by leaps and bounds. Still another major camera manufacturer has incorporated a NEG'ATOR motor as the drive unit in a new model. New application stories become available regularly. Many of the predictions made for the NEG'ATOR (by design engineers like yourself) are being realized.

To keep you up-to-date at all times, we are now publishing the NEG'ATOR Sketchbook shown at left. By means of regular issues, we intend to make available to you all types of NEG'ATOR information—new data, new developments, functions, applications, and ideas.

If you will write us, we will be happy to send you all past issues of this publication and add your name to our list for future issues. Contact us today. Ask for the Sketchbook.

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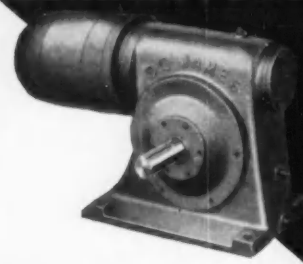
D.O.James GEARMOTORS



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They cover a very wide range of ratios, horsepowers, and are an ideal, compact, efficient unit for many power and space-saving installations. They are designed and built by an organization that has been engaged in the manufacture of Gears for 70 years and that has successfully pioneered the Gear Speed Reducer to its present-day high standards.

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Catalogs, price lists and selection tables covering gear speed reducers and gearmotor speed reducers are available to power transmission engineers. Please request on company Letterhead — we'll mail your copy at once.

PRESS PREVIEWS

Lab to Establish Electrical Standards

As part of a general expansion, an electrical standards lab has been established by Humphrey, Inc., a San Diego, Calif. manufacturer of electromechanical instruments. The new standards lab will maintain accuracy of all electrical test instruments of the engineering development, production and inspection departments.

The newly-formed section, isolated from all other plant activities, will calibrate electrical instruments by comparison with suitable "standard instruments." Design and location assures a clean atmosphere, vibration-free environment, and a relatively constant ambient temperature. All activities that would affect stability or accuracy of precision electrical instruments are confined to an area outside the lab.

Powdered Metal Fabricators to Expand

Chicago Powdered Metal Products Co., Schiller Park, Ill. fabricator of powdered metal parts, is expanding its plant and equipment. The expansion will provide molding presses up to 300 tons that will accommodate powdered metal parts to 15 in. dia. Cost of expansion is estimated at $150,000, and is planned for completion by the first of the year.

Crucible Steel Lab for Syracuse

An applied research lab will be established by Crucible Steel Co. at its

(Continued on page 207)

FREE TEST SAMPLES
Show How
MINI-MITE
miniaturized
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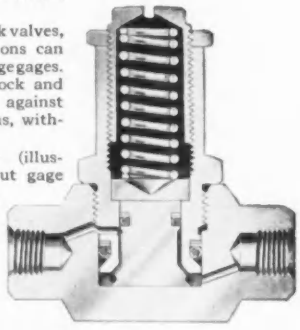

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New Plant for New Plastic

A large-scale plant to manufacture "Delrin" acetal resin, a new plastic material developed under Du Pont's fundamental research program, will be built near Parkersburg, W. Va. The plastic is expected to be in commercial production by mid-1959. Completion of the new unit will add 120 employees to the Washington Works operating force.

"Delrin", which has been under development in Du Pont labs for a number of years, is a thermoplastic that can be molded or extruded by plastics processors for a variety of uses. It is tough and rigid, with high tensile strength, high melting temperature, dimensional stability, and resistance to deformation under stress.

Lab Gives Push to Urethane

Automated prototype equipment for molding cushions of urethane foam has been demonstrated at Du Pont's

(Continued on page 208)

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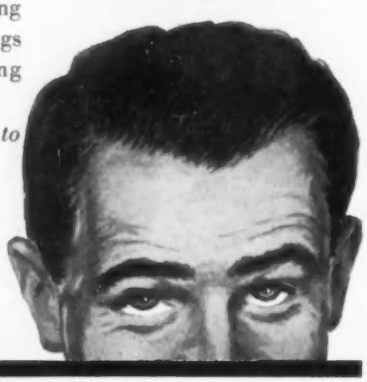

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new urethane foam lab in Wilmington, Del. The new $500,000, 6,000-sq-ft lab has been built to help customers evaluate equipment and techniques used in manufacture of urethane foam products. It is an addition to the product development laboratory of Du Pont's Elastomer Chemicals Department.

Transistor Boom Spawns New Firm

Fairchild Semi-Conductors Corp. has been formed in Palo Alto, Calif. To develop and produce silicon diffused transistors and other semi-conductors. First products to be offered will be a high-speed computor transistor to be followed by transistors to serve vhf power oscillators, vhf amplifiers, and very high power applications at lower frequencies.

Million-dollar Magnetic Tape Plant Coming

A plant designed specifically for magnetic tape manufacture will be built in Danbury, Conn. by Reeves Soundcraft Corp., New York and Los Angeles. Tapes to be manufactured will range from those used to receive information from U. S. earth satellites to those for high fidelity recording. The 50,000-sq-ft plant, scheduled for completion in mid 1958, will cost over $1 million, will employ about 150 initially.

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Index of
PRODUCTS ADVERTISED
In This Issue

A

Actuators
  Mechanical 61
Adhesives 183
Aluminum Alloys 29-30
Aluminum Coated Sheet and Strip (see Steel, Coated)
Axles 154

B

Bars
  Metal 2, 65
Bearing Materials 18-19
Bearings
  Ball 13, 36, 42, 70, 127, 138, 161, 169, 181, 192
  Miniature 138
  Needle 161
  Roller 13, 24-25, 42, 138, 161
  Self-Lubricating 208
  Sleeve 186
Belts, Timing 20-21
Belts, V 35, 37, 39, 41
Bi-Metal 189
Books 190
Brakes
  Electric 173
Brass 38
Brazing
  Alloys 199
Bronze 117, 208
Bushings 208
Bushings, Strain Relief 154

C

Cam Followers 127, 161
Capacitors 11
Castings, Precision Investment 122
Chains
  Conveyor 20-21, 156, 185, 205
  Roller 20-21, 156, 185, 205
  Silent 20-21
Chemical Treatments 180
Cleaners, Metal 159
Clutches
  Electrical 173
  Mechanical 20-21, 136, 150, 173, 212
Coatings 164, 180, 183
Connectors
  Electrical 124
Contacts & Contact Materials 27
Controls
  Electrical 33-34, 47-50
  Electronic 33-34
  Hydraulic 141
  Mechanical 162
Copper & Copper Alloys 38
Couplings (see Connectors, Electrical)
Couplings
  Hose 147
  Hydraulic 176
  Mechanical 20-21, 136, 174, 176
  Tube 147
Cylinders
  Hydraulic 191

D

Decalcomanias 202
Die Castings 45, 62-63, 137, 143, 152
Discs, Clutch & Brake 173
Drafting
  Machines 22-23
  Supplies 22-23
Drives
  Adjustable Speed 1
  Mechanical 64
  Right-Angle 187
  Variable Speed 20-21, 160, 172, 184, 187

E

Engineering Services (see also Production Services) 32, 47-50, 188
Engines 196
Expanded Metals 175
Extrusions
  Metallic 65, 129, 163
  Non-Metallic 146

F

Fabricated Plastics (See Plastics, Fabricated)
Fabricated Steel (see Plate, Fabricated, Sheet Fabricated, Structural Forms & Shapes, see Weldments)
Fastening Methods 68, 130
Fibre 51, 60, 206
Filters
  Air 46, 192
  Hydraulic 141
Fittings, Hose, Pipe & Tube 147, 197
Flexible Couplings 20-21, 174, 185
Flow Regulators 141
Forgings 18-19, 163, 192
Friction Materials 54
Furniture, Engineering Dept. 22-23, 55

G

Gaskets 206
Gear Motors (see also Motor Reducers) 47-50, 134, 160, 165, 172, 204
Gears 6, 153, 204

H

Hard Surfacing 10, 56
Heating Units 179
Hose & Tubing 53

I

Insulation 140

J

Jacks, Electrical 4

L

Lamps, Indicating 182
Laminated Plastics (see Plastics, Laminated)
Lubricants 164, 202

M

Magnesium Alloys 44
Magnets 178
Metal Bonded to Plastic 148
Moldings
  Plastics (see Plastic Parts)
  Powdered Metal (see Powdered Metal Parts)
  Rubber (see Rubber Parts)
Motor Reducers (see also Gear Motors) 47-50, 160
Motors, A-C
  Fractional 52, 57, 160, 165, 168
  Integral 52, 168, 172
Motors, D-C
  Fractional 47-50, 52, 57, 115, 165, 168
  Integral 47-50, 52, 115, 168, 172
Motors, Hydraulic 191

N

Name Plates 196, 202
Nickel Alloys 32
Nuts 12, 137, 202

P

Phosphor Bronze 201
Pillow Blocks 70
Pilot Lights 27
Pipe 65
Plastic Parts 116, 137
Plastics 16-17, 58-59, 186
Plastics Fabricated 51, 116, 186
Plastics Laminated 51, 116, 131, 139, 148
Plates 144
Plugs 4
Powdered Metal Parts 152
Power Take-offs 150
Production Services (see also Engineering Services) 38, 47-50
Pumps
  Liquid 191

R

Relays 11, 31, 120, 200
Resins 16-17, 26
Resistors 11
Retaining Rings 158
Rheostats 11
Rings & Loops 177
Rivets 130
Rods
  Metallic 18-19, 117
  Non-Metallic 51, 131
Rubber 142, 146
Rubber-Bonded-to-Metal 142
Rubber Parts ..... 3rd Cover

S

Screws 204
Screw Thread Inserts 198
Sealants 135
Seals ..... 3rd Cover, 195
Seating Work Equipment 206
Shapes, Rolled Formed 171
Sheaves 35, 37, 39, 41
Sheets
  Metal 2, 65
  Plastic 51, 131
Silver Alloys 199
Solenoids 28
Spacers 171
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 68
Speed Reducers ..... 2nd Cover, 20-21, 150, 160, 187, 204
Spindles 154
Splines 61
Springs 170, 196, 200, 203, 208
Sprockets 20-21, 156, 185, 205
Stampings 170, 188, 196
Steel
  Alloy 155
  Coated 43
  Stainless 2, 38, 65, 149, 155
Strip, Metallic 2, 65, 201
Structural Forms & Shapes 117
Switches 11, 33-34

T

Thermostats 8, 15
Timers 193
Timing Motors 193
Transformers 11
Tubing
  Flexible Metal 53
  Plastic 51, 131
  Seamless 14

V

Valves
  Air 66, 132, 141, 166-167
  Hydraulic 40, 66, 132, 145, 191, 206
  Solenoid 40, 66, 166-167
Vibration Dampers
  Mechanical 186

W

Washers 151, 158
Washers (see Packings)
Wear Materials 208
Welding
  Equipment 157
  Nuts 200
  Supplies 157
Weldments 177
Wheels 154
Wire 2, 65
Wire Cloth 133, 194, 207
Wire Forming 170, 196

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INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

AMP, Inc. 124
Accurate Spring Mfg. Co. 170
Acme Chain Corp. 156
Acushnet Process Co. 142
Advance Stamping Co. 188
Aeroquip Corp. 147
Air-Maze Corp. 192
Ajax Flexible Coupling Co. 174
Allegheny Ludlum Steel Corp. 155
Allen-Bradley Co. 33-34
Allied Research Products, Inc. 180
Allis-Chalmers Mfg. Co. 52
Alloy Precision Castings Co. 122
Alpha Molypote Co. 202
American Crucible Products Co. 208
American Hard Rubber Co. 146
American Metal Hose Div., American Brass Co. 53
American Smelting & Refining Co. 117
American Welding & Mfg. Co. 177
Amforge Div., American Brake Shoe Co. 192
Armco Steel Corp. 2
Atlas Chain & Mfg. Co. 185
Automatic Electric Sales Corp. 120
Automatic Switch Co. 66

B

Bakelite Co., Div., Union Carbide Corp. 16-17
Bethlehem Steel Co. 68
Blood Brothers Machine Div., Rockwell Spring & Axle Co. 64
Boston Gear Works 153
Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co. 132
Bruning Co., Inc., Charles 22-23
Bushings, Inc. 186

C

Cambridge Wire Cloth Co. 194
Century Electric Co. 165
Chace Co., W. M. 189
Chase Brass & Copper Co. 38
Chattillon & Sons, John 208
Clare & Co., C. P. 31
Cleveland Worm & Gear Co. ..... 2nd Cover
Comar Electric Co. 200
Commercial Shearing & Stamping Co. 191
Crucible Steel Co. of America 149

D

Detrex Chemical Industries, Inc. 159
Doehler-Jarvis Div., National Lead Co. 62-63
Dow Chemical Co. 44
Dudek & Bock Spring Mfg. Co. 196
du Pont de Nemours & Co. (Inc.), E. I., Textile Fibers Dept. 60
Dynamatic Div., Eaton Mfg. Co. 1

E

Electric Wheel Co. 154
Electro Dynamics Div., General Dynamics Corp. 172

F

Fairbanks, Morse & Co. 168
Federal Mogul Div., Federal-Mogul-Bower Bearings, Inc. 171
Fenwal, Inc. 15
Foote Bros. Gear & Machine Corp. 187
Formica Corp., Subs., American Cynamid Co. 139
Formsprag Co. 212

G

General Electric Co., Apparatus Dept. 115
General Electric Co., Miniature Lamp Dept. 182
Gleason Works 6
Gries Reproducer Corp. 137

H

Handy & Harman 199
Haydon Mfg. Co., Inc. 193
Heli-Coil Corp. 198
Heyman Mfg. Co. 154
Hilliard Corp. 136
Hoover Ball & Bearing Div. 169
Hunter Douglas Aluminum Corp. 163
Hunter Spring Co. 203
Hyatt Bearings Div., General Motors Corp. 24-25

I

Indiana Steel Products Co. 178
Inland Steel Co. 144
International Nickel Co., Inc. 32

J

James Gear Mfg. Co., D. O. 204
Jeffrey Mfg. Co. 205
Johns-Manville Corp., Industrial Friction Materials 54
Johnson Machine Co., Carlyle 173
Jones & Laughlin Steel Corp. 129

K

Kaiser Aluminum & Chemical Corp. 29-30
Kilian Mfg. Corp. 192

L

Lincoln Electric Co. 157
Linde Co., Div. of Union Carbide Corp. 10, 56
Link-Belt Co. 13

M

McGill Mfg. Co., Inc. 127
McGraw-Hill Book Co. 190
Mack Molding Co. 186
Madison-Kipp Corp. 143
Mallory & Co., Inc., P. R. 4
Marbon Chemical Div., Borg-Warner Corp. 26
Mechanical Air Controls, Inc. 166-167
Meyercord Co., Name Plate Div. 202
Michigan Tool Co., Cone-Drive Gears Div. 134
Milford Rivet & Machine Co., The 130
Miller Co. 201
Miller Dial & Name Plate Co. 196
Milsco Mfg. Co. 206
Minnesota Rubber & Gasket Co. ..... 3rd Cover
Mobay Chemical Div. 58-59
Morse Chain Co. 20-21
Mueller Brass Co. 18-19

N

National Acme Co. 28
National Lock Washer Co. 158
National Machine Products Co. 202
National-Standard Co. 133
Newark Wire Cloth Co. 207
New Departure Div., General Motors Corp. 70
New Hampshire Ball Bearings, Inc. 138
Nice Ball Bearing Co. 181
Norgren Co., C. A. 46

O

Ohio Nut & Bolt Co. 200
Ohmite Mfg. Co. 11

P

Pack Mfg. Co. 55
Packard Electric Div., General Motors Corp. 57
Parker-Hannifin Corp. 195
Parker Rust Proof Co. 164
Parker White Metal Co. 152
Penn Metal Co., Inc. 175
Pierce & Stevens Chemical Corp. 183
Presstite-Keystone Engineering Products Co., Div., American-Marietta Co. 135

R

Reeves Pulley Co., Div., Reliance Electric & Engineering Co. 184
Republic Mfg. Co. 206
Richardson Co. 116
Robertshaw Thermostat Div., Robertshaw-Fulton Controls Corp. 162
Rockford Clutch Div., Borg-Warner Corp. 150
Rubatex Div., Great American Industries, Inc. 140

S

SKF Industries, Inc. 42
Saginaw Steering Gear Div., General Motors Corp. 61
Sandsteel Spring Div., Sandvik Steel, Inc. 200
Set Screw & Mfg. Co. 204
Shakeproof Div., Illinois Tool Works 151
Spaulding Fibre Co., Inc. 51
Spray Engineering Co. 197
Square D Co. 27
Standard Pressed Steel Co. 12
Stephens-Adamson Mfg. Co. 36
Sterling Electric Motors, Inc. 160
Stevens Mfg. Co., Inc. 8
Stewart Die Casting Div., Stewart Warner Corp. 45
Synthane Corp. 131

T

Taylor Fibre Co. 148
Timken Roller Bearing Co., Steel & Tube Div. 14
Torrington Co. 161

U

U. S. Graphite Co., Div. of the Wicks Co. ..... 4th Cover
U. S. Steel Corp. 65

V

Vellumoid Co. 206
Vickers, Inc., Div. of Sperry-Rand Corp. 40

W

Waldron Corp., John 176
Waterman Engrg. Co. 141
Watlow Electric Mfg. Co. 179
Webster Electric Co., Oil Hydraulic Div. 145
Weirton Steel Co., Div., National Steel Corp. 43
Westinghouse Electric Co. 47-50
Wisconsin Motor Corp. 196
Worthington Corp. 35, 37, 39, 41

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EMPLOYMENT OPPORTUNITIES 210
Index to Advertisers begins on P 211
Products Index begins on P 209

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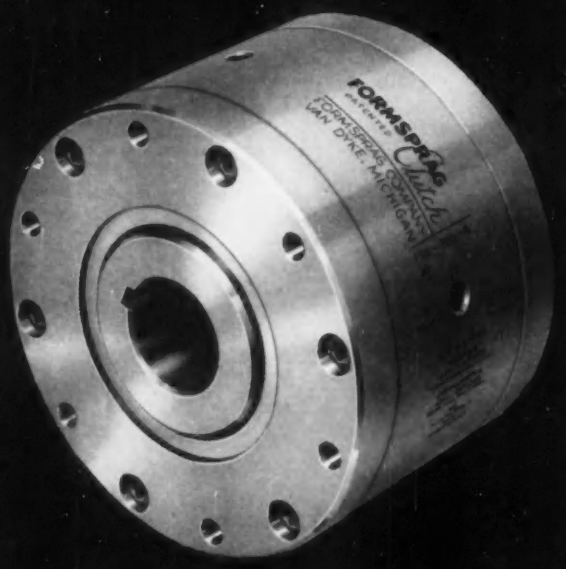

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The "B" is intended for over-running applications where both races rotate during some portion of the operating cycle. The "C" series should be selected if the application is one of indexing or if the outer race is to be fixed, as in a backstopping application.

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CHECK THESE CAPACITIES

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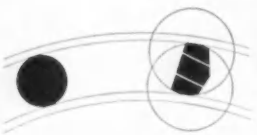
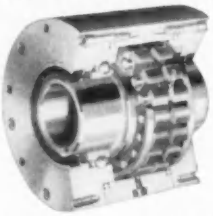
FSB & FSC-750	600	3,160	2¼"
FSB & FSC-800	600	4,200	3½"
FSB & FSC-900	600	6,000	4½"
FSB & FSC-1000	500	11,600	5½"

WHY IT PAYS TO DESIGN "THE FORMSPRAG PRINCIPLE" INTO YOUR PRODUCT

Sprags are an advanced design of precision wedges made of hardened alloy steel. Utilized in a clutch, they increase the efficiency and prolong the life of all equipment using an over-running clutch or ratchet.



The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space—therefore, of increased torque capacity.



Designed for backstopping, indexing and low speed over-running service where inner race over-runs. Formsprag will make selection of either "B" or "C" series when application data sheet accompanies order.

MORE INFORMATION?

Should you require details on these Formsprag small clutches as well as the complete line, write today for this new 26-page catalog.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

FORMSPRAG COMPANY

23607 HOOVER ROAD, VAN DYKE (DETROIT), MICH.

World's largest exclusive manufacturer of over-running clutches. Distributors in principal cities.

A7-11C

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about

- **products advertised**
- **new components and materials**
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Now, one of these handy prepaid postcards will bring you more information about any product advertised or mentioned editorially in this issue of *Product Engineering*.

Here's How to Use the Card

For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 167-172.

To get more data about new Components, Materials and Parts fully described on pages 125-162, just circle the appropriate key number.

To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T—Top; B—Bottom; R—Right; L—Left; TL—Top left; BL—Bottom left; TR—Top right; BR—Bottom right.

For specialized data . . . prices, sizes available, nearest source of supply, etc. . . . do not circle key number but indicate your needs in the space allotted at the bottom of the card. Use this space, too, if information about a specific product among several mentioned in an advertisement is desired.

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NEW COMPONENTS AND MATERIALS . . .

Description of these new engineering materials appear on pages 125-162. Circle key number for motor data

1—Multiple-speed and Takeoff Transmission in Sizes up to 60 hp

2—Glass, Quartz-reinforced Teflon

3—Differential Pressure Operates Automatic Air Line Oiler

4—Compression Fastener

5—Oil-submerged Motor Operator

6—High-strength Lock Washer

7—Subminiature Pressure Snubbers

8—Vibration-monitoring System

9—Multi-purpose Miniature Switch

10—Snubber Guards Air Gages

11—Non-reset Counters

12—High-pressure Valves

13—Self-taping Insert

14—Vinyl to Metal Primers

15—Teflon-lined Pipe, Ells, Tees

16—Blind Fasteners

17—Self-locking Nut

18—Electrical Insulation Tubing

19—Copper-clad Teflon Sheet, Tape

20—High-speed Sampling Switch

21—Miniature AC Motor

22—Explosionproof Pressure Control

23—Sectional Terminal Blocks

24—All-glass Y-type Valve

25—Universal Shim-Nuts

26—Bearing Temperature Indicator

27—Temperature-indicating Ribbon

28—Pushbutton Switch

29—Heavy-duty Flasher

30—High-torque Differential

31—Explosionproof Circuit Breaker

32—Chain Oiler

33—Machine Tool Switch

34—Boards and Standardized Bases

35—In-plant Data Handling

36—Transistor-equipped Relay

37—Right-angle Gear Motors

38—Aluminum Instrument Knobs

39—Rotor Moves Brushless Alternator

40—Explosionproof Switches

41—Portable Potentiometer

42—Electronic Symbols Template

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C2	1	2	4	6	8	10	11	12	13
14	15	16-7	18-9	20-1	22-3	24-5	26	27	28
29-30	31	33-4	35	36	37	38	39	40	41
42	43	44	45	46	47-50	51	52	53	54
55	56	58-9	60	61	62-3	64	65	66	68
70	115	116	117	120	122	124	127	129	130
131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150
151	152	153	L154	R154	155	156	157	158	159
160	161	162	163	164	165	166-7	168	169	171
172	173	174	175	176	177	178	179	180	181
183	184	185	L186	R186	187	L188	189	190	191
T192	BL192	BR192	193	194	195	L196	TR196	BR196	197
198	199	L200	TR200	BR200	201	T202	BL202	BR202	203
L204	R204	205	L206	TR206	BR206	207	T208	B208	212
C3	C4								

NEW COMPONENTS AND MATERIALS

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42								

NEW CATALOGS AND BULLETINS

43	44	45	46	47	48	49	50	51	52
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45—Electrical Contacts—4 pp. Contacts, Inc.

46—Silicone Sponge Rubber Sheets—2 pp. Connecticut Hard Rubber Co.

47—Variable Speed V-Belts—32 pp. Industrial Div., Dayton Rubber Co.

48—Stainless Fasteners—48 pp. Allmetal Screw Products Co., Inc.

49—General-duty Master Switch—2 pp. General Electric Co.

50—PVC Pipe—32 pp. A. M. Byers Co.

51—Commercial Fasteners—12 pp. Huck Mfg. Co.

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53—Electrical Conduit and Cable Fittings—62 pp. Thomas & Betts Co.

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55—Tube and Bar Stock—6 pp. Shenango Furnace Co.

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57—Switches—36 pp. Globe-Union

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PRODUCTS ADVERTISED

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141	142	143	144	145	146	147	148	149	150
151	152	153	L154	R154	155	156	157	158	159
160	161	162	163	164	165	166-7	168	169	171
172	173	174	175	176	177	178	179	180	181
183	184	185	L186	R186	187	L188	189	190	191
T192	BL192	BR192	193	194	195	L196	TR196	BR196	197
198	199	L200	TR200	BR200	201	T202	BL202	BR202	203
L204	R204	205	L206	TR206	BR206	207	T208	B208	212
C3	C4								

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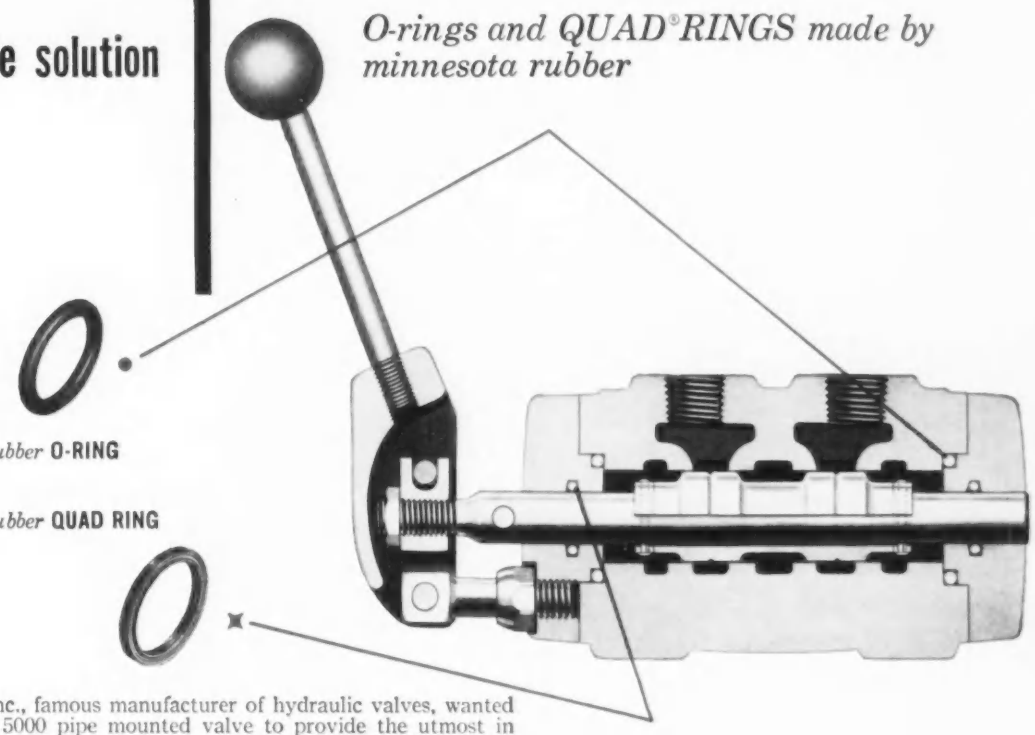
hydraulics problem

how to eliminate gaskets and reduce friction to improve design of a pipe mounted valve

simple solution

O-rings and QUAD® RINGS made by minnesota rubber



minnesota rubber **O-RING**

minnesota rubber **QUAD RING**

RIVETT, Inc., famous manufacturer of hydraulic valves, wanted their Series 5000 pipe mounted valve to provide the utmost in simple, smooth, leakproof operation. A special *floating piston* was incorporated in the design of the valve. This exclusive feature eliminated sticking or binding by keeping the valve stem independent of the bore. To provide a stem seal that would greatly reduce friction, RIVETT chose the Minnesota Rubber QUAD RING. This exclusive seal provided a perfect seal with much less squeeze making operation easier. To obtain design simplicity, more efficient operation and longer life, gaskets were eliminated and replaced by Minnesota Rubber O-Ring cover seals. This combination of advanced design elements and Minnesota Rubber Seals permits multi-million cycle operation at 1500 PSI.

What Minnesota Rubber Seals offer you. An exclusive injection molding process means that Minnesota Rubber QUAD RINGS, O-Rings and other rubber parts are denser and tougher. Their tremendous uniformity and strength mean greater dependability, longer life. Quad Rings give you 4-lip sealing action, seal at less than 1 PSI, require only 60-100 micro-inch groove finish and eliminate "spiral twist." Minnesota Rubber O-Rings are available to you with tolerances as close as ± .002″, cost as little as ordinary O-Rings and are produced with no flash or other imperfections that require trimming. An enormous selection of standard sizes assure immediate delivery.

Note: QUAD RING is a Trade Mark of the Minnesota Rubber & Gasket Co.

Free samples and data. A sample of Minnesota Rubber seals is available together with complete technical data. Simply write . . .

minnesota rubber and gasket company

Originators of modern rubber injection molding.

Dept. 204, 3630 Wooddale Ave., Minneapolis 16, Minnesota; Phone: WEst 9-6781

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you can improve your product with

GRAMIX®

(PRODUCT OF POWDER METALLURGY)

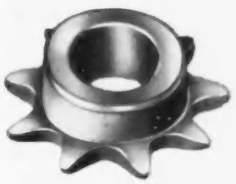
PRECISION FINISHED PARTS

GRAMIX precision finished parts are improving products in virtually every branch of industry. A pump manufacturer, for instance, may specify a gasoline pump rotor made of GRAMIX and gain a number of advantages.

To begin with, the alloys are carefully blended to meet his individual requirements. The GRAMIX parts are then die-pressed to exact shape, sintered under rigid control and finished to tolerances as close as .0005". (This process, of course, costs far less than machining, forging or casting.) The manufacturer can expect the GRAMIX gasoline pump rotor to do a better job because *all* GRAMIX parts are precision engineered and precision controlled from alloying to finishing.

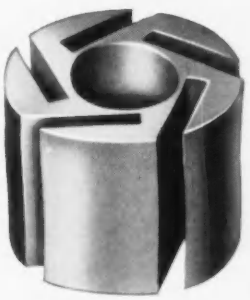
No matter what the application may be, GRAMIX parts fit specifications exactly. Parts may be impregnated with oil . . . to insure a longer life and a quieter operation: if specified, the GRAMIX parts may be coined and work hardened, even prepared for plating.

The rotor is only one of thousands of applications in which GRAMIX precision parts have proved to be ideal. Just a few of them are shown here, so consider the components of your products . . . there may be several that could be improved . . . with GRAMIX! Products of powder metallurgy you can rely on.



Hardened steel drive sprocket for lawnmower

Iron switch control



Rotor for gasoline pump

Packing gland follower used in hydraulic system

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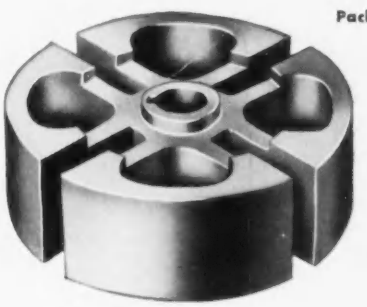

Bronze rotor in high speed fueling unit

X-245-1

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